AIRCRAFT & MISSILES

A Chilton Publication APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES February 1961

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WHICH MATERIALS FOR PROPULSION SYSTEMS? . . . P 24

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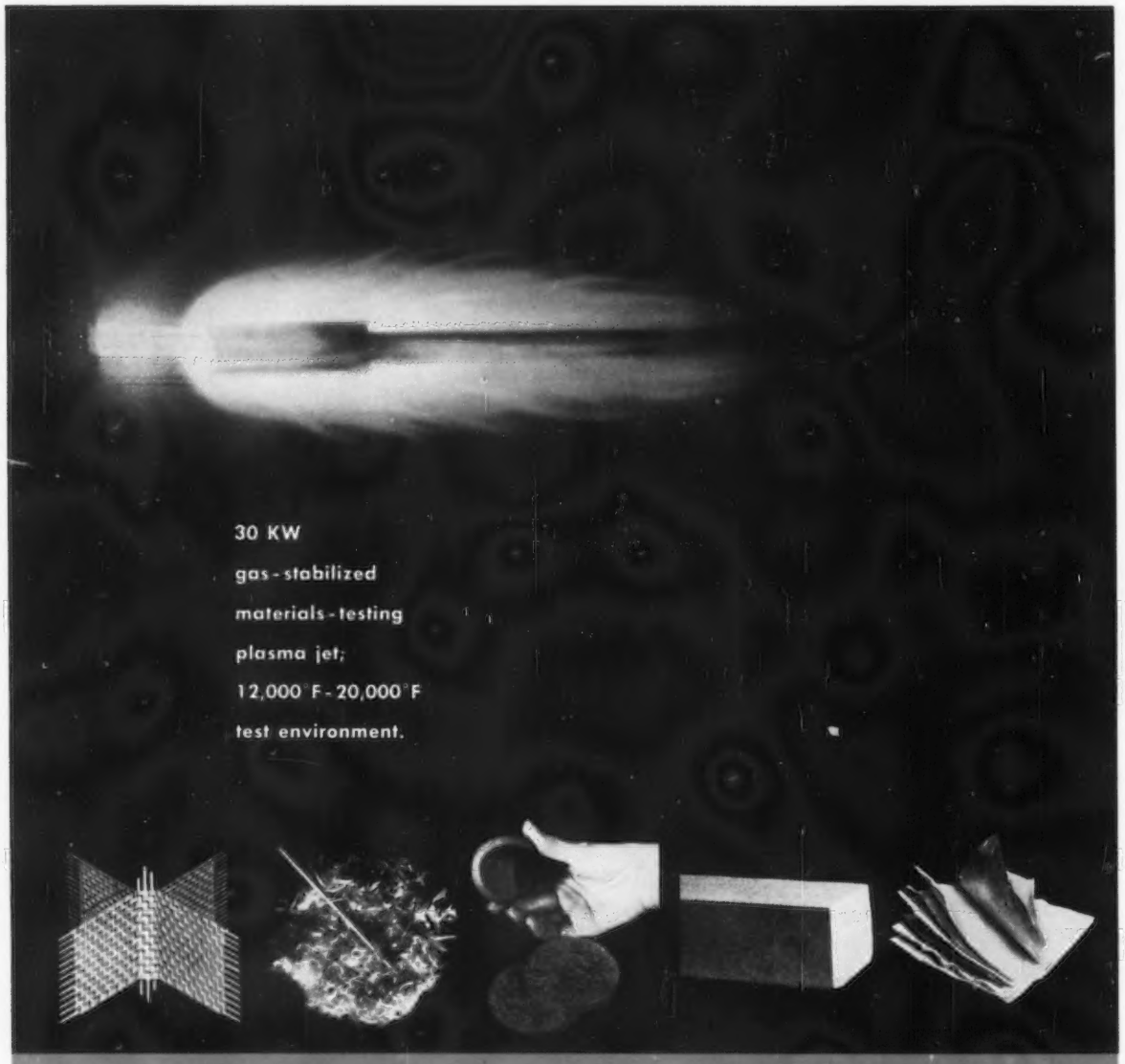
A Giant Market And A Giant Challenge



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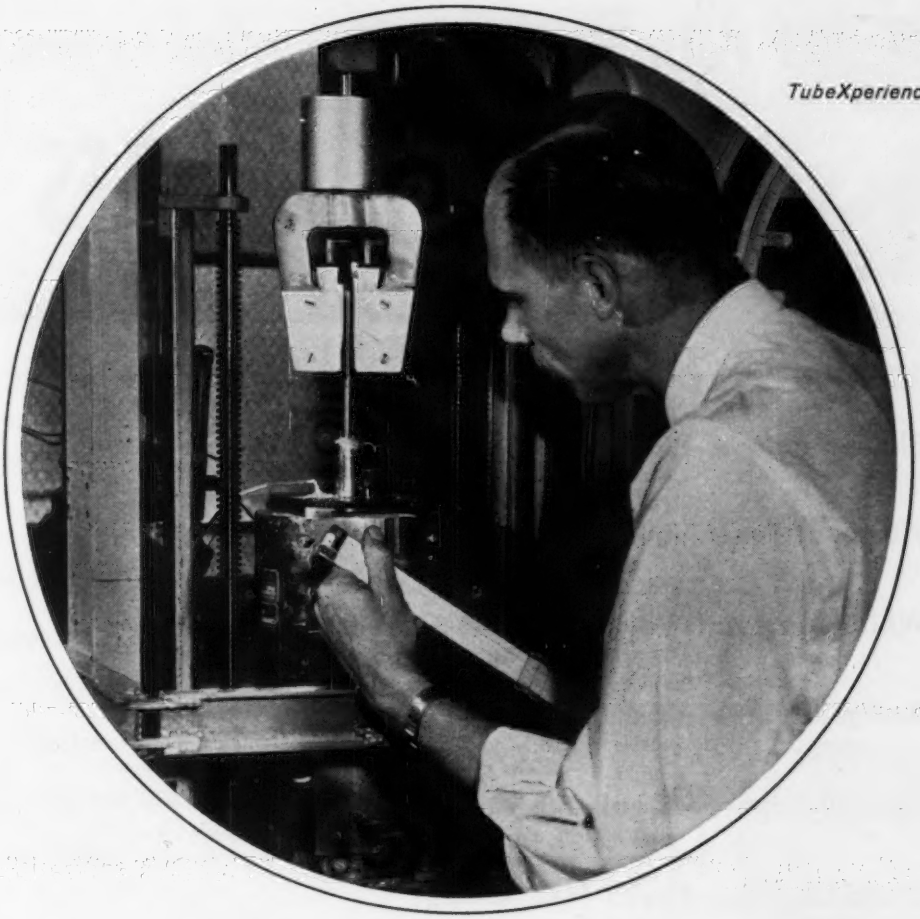

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February, 1961 *Volume 4, Number 2*

AIRCRAFT & MISSILES

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THE COVER STORY—Propulsion experts agree that chemical propellants will do the "workhorse" jobs in space exploration during the next decade. The market for better propellants is a great challenge to the chemical industry. This month's cover shows a conceptual Mars vehicle being serviced in Earth-orbit in preparation for the flight. It would use chemical propellants. Other markets await the alert chemical companies in the Aerospace Industry . . . See Challenge and The Progress, page 32.

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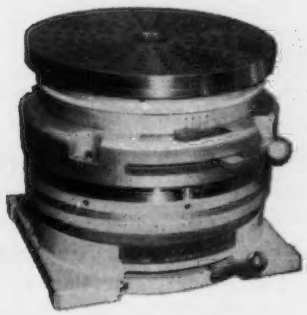

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Will Skybolt Be Shot Down?

Skybolt under B-52H released. But, where'd it go? Already the program lacks financing.

Some military observers outside of Air Force claim B-52 will be obsolete missile platform by time Skybolt becomes operational. Wait for the B-70; it'll be here by then is the cry. So why have Skybolt? It won't fit B-70 design.

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Again and again, people want to hold up progress for a more dramatic breakthrough. No one is *really 100 per cent sure* B-70 will fly on schedule. When toying with the national defense, let's pick up the birds at hand while we explore the bush.

After all, man has not gone through sustained Mach 3 flight at the upper reaches of space. We don't know exactly what is in store. Sure, what we hope to be accurate estimates are made. Our aircraft designers are good—no need for the trial and error test pilots of yesteryear.

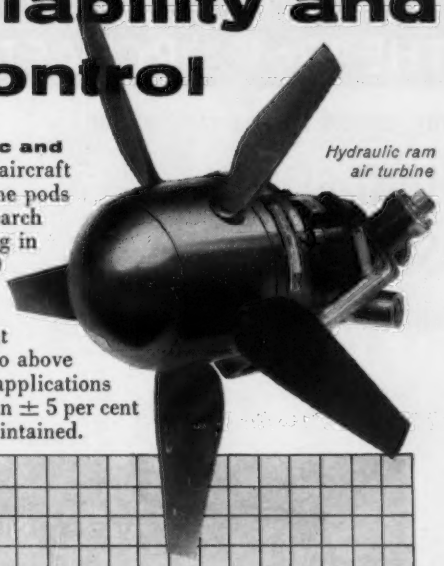
Just remember, skeptics who wait for that next breakthrough, this earth has been in existance more years than anyone knows—we still haven't found a method for clearing snow. Until we do, we'll use our plows and shovels rather than suffer economic chaos. Don't get buried six feet under just waiting without grasping at each means of survival.

Tom MacNew
Editor

AiResearch ram air turbines unequalled in reliability and fine speed control

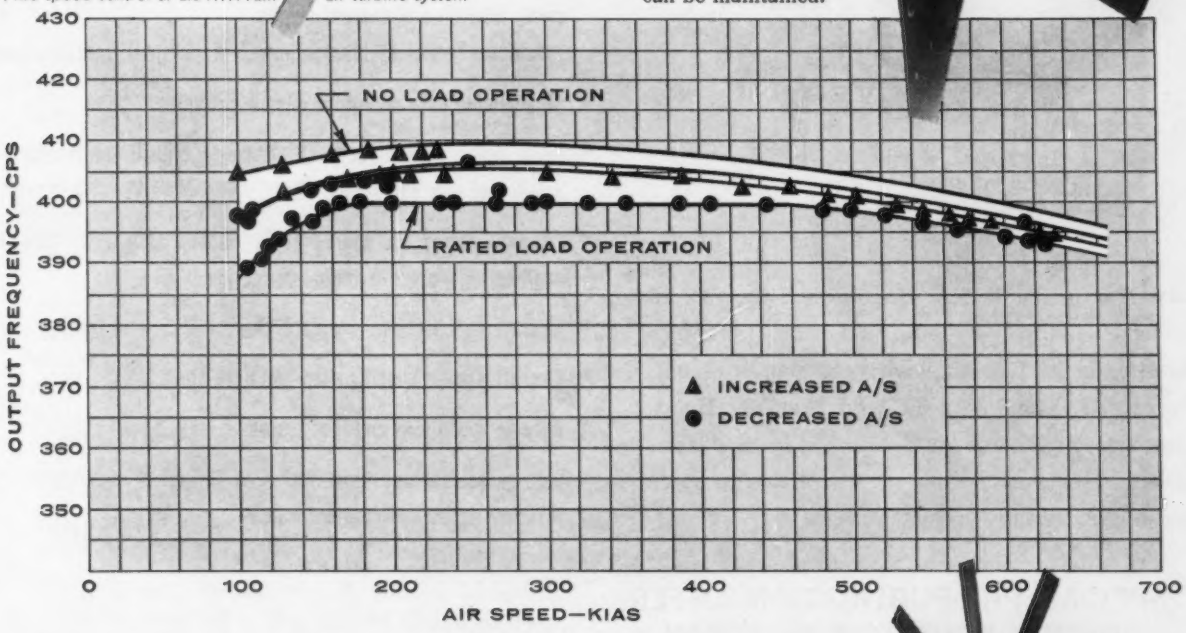
Electrical ram air turbine

In-flight hydraulic and electrical power for aircraft emergency use and airborne pods is supplied by AiResearch ram air turbines ranging in size from fractional to 100 horsepower. The fine speed control regulates the turbine to ± 5 per cent from aircraft design speed to above Mach 1. For special electrical applications frequency control lower than ± 5 per cent can be maintained.



Hydraulic ram air turbine

Fine speed control of 2.5 KVA ram air turbine system



As an emergency power source, the ram air turbine provides sufficient hydraulic power, electrical power or a combination of both for operation of the aircraft's basic controls in the event of main engine failure.

Ram air turbines also serve as auxiliary power supply systems, particularly in remote locations where independent power supplies offer optimized design. For example, they supply continuous electrical power to operate electronic equipment within aircraft-carried pods. Other areas of ram air turbine application include high speed drones and STOL aircraft.

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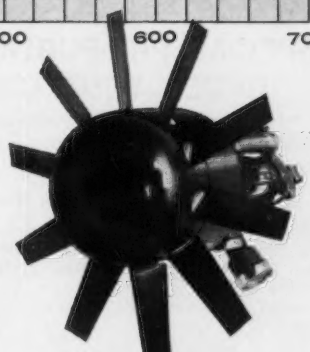

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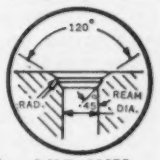

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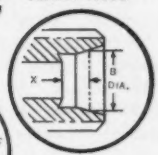

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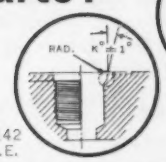

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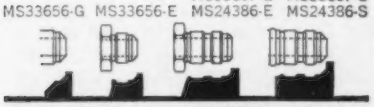

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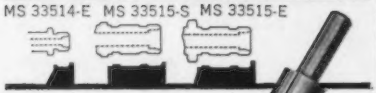

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National Professional Group on Military Electronics and Los Angeles Section, Institute of Radio Engineers
Biltmore Hotel, Los Angeles

February 4-6
Golden Gate Metals Conference
Golden Gate Chapter, American Society for Metals
Fairmont Hotel, San Francisco

February 22-March 10
Government Contracting Course
National Defense Education Institute
New York, N. Y.

February 14-15
Conference on Coatings for Aerospace Vehicles
Air Materiel Command
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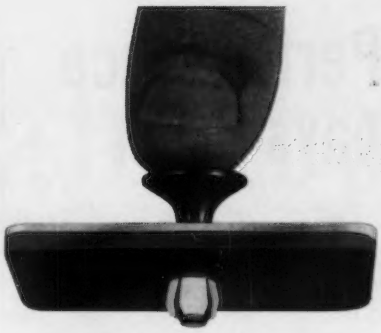
February 14-16
Second Annual Symposium on Nondestructive Testing of Aircraft and Missile Components
South Texas Section, the Society for Nondestructive Testing Inc. and Southwest Research Institute
Gunter Hotel, San Antonio, Texas

February 15-17
International Solid-State Circuits Conference
Institute of Radio Engineers
Sheraton Hotel, Philadelphia

February 26-March 1
Pacific Electronic Trade Show
Great Western Exhibit Center
Los Angeles

March 5-9
Sixth Annual Gas Turbine Conference and Exhibit
American Society of Mechanical Engineers
Shoreham Hotel, Washington, D. C.

March 9-10
Flight Propulsion Meeting
Institute of the Aeronautical Sciences
Cleveland, Ohio



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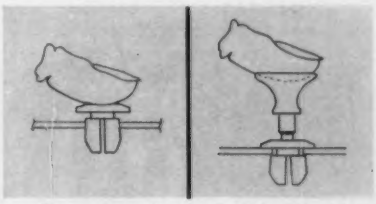

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Reader's Orbit

Vicious Procurement Practices

. . . the problems involved in "rights and data" portions of Government Contracts are truly a great injustice and a sure road to complete extinction of our country's free enterprise system . . . We are very pleased you continue to bring case histories to your readers . . . We urge your continuance, and feel confident that other manufacturers will stand up and be counted and bring forward the atrocities which they have encountered in doing business with DOD.

. . . it is not our desire to bicker with our government, we find it extremely distasteful to be forced to do so. However, we do not intend to stand by and quietly watch the very extinction of the American Free Enterprise System . . .

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More On Practices

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And Then There Were None

. . . Was very much impressed by the lighter-than-air design of the Polaris Guidance System (Dec. Data Capsule . . . "Polaris guidance system will be lightened by over 100 percent in the advanced version of the missile.") We would like to accomplish same saving on some of our units. Please explain this exceptional approach.

Conrad Trybus
Design Engineer
Elect. Equip. Dept.
Chrysler Corp.

Weight of guidance system in advanced Polaris has been halved. Only explanation for the "weightless" guidance system is a light-headed editor too long in orbit.

December Plaudits

. . . Your special report, Army Tells Industry, Dec., 1960, has drawn overwhelming praise from personnel at Army Rocket and Guided Missile Agency . . . am interested in distributing a copy of it to all of our management personnel. To accomplish this I would need a thousand copies.

Werner H. Fornos
Information Officer
ARGMA, Huntsville

. . . We are happy to have assisted in the preparation of the report (Army Tells Industry). It is well done. Please let me know when we can be of help in the future.

William W. Quinn
Major General, GS
Chief of Information, Army

. . . Think the Navy article (special report "Navy, What They Have and What They Need") in your December issue is real good. Congratulations. Happy to see SARATOGA'S picture used . . . We think CVA's are essential ingredient of Navy's total capability.

Roger W. Mehle
Captain, USN
Commanding Officer
USS Saratoga

Working Aids

Reprint requests for A & M's special report "Military Tells Industry" will be honored as long as the supply lasts. It is rapidly depleting.

. . . Recently received my issue of A & M, January . . . there are several articles which touch upon my present job scope and will definitely become working aids . . . send reprints of: Saturn Booster for the Sixties; Guidance and Secondary Power Needs; NASA's Goals For Next Decade; Thiokol Forecasts Solids For 60's; Aerojet Forecasts Liquids For 60's; Aerospace Structures Gap; Design Details of Nova's Booster.

H. A. Lieske
Systems Project Engineer
Advanced Space Vehicle Eng.
General Electric-MSVD

Preserving The Lifeblood

. . . Just read your article "Can DOD Seize Patent Rights?" A JOB WELL DONE . . . certainly hope that your efforts on behalf of the American public will alert our peoples to the point where they will take positive action to preserve our patent system which is the lifeblood of our free enterprise system. While the Robbins organization is small in size, we are constantly having to strive to preserve our patent rights. In fact, we are plagued with three more cases similar to the one referred to in your article. Well-written articles, such as yours, will do a great deal toward strengthening this cause.

Hugh C. Robbins
President
Robbins Aviation, Inc.

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Kollsman has been designing and manufacturing special-purpose control motors of high precision for 19 years. More than 1,000 different Kollsman-designed motors now exist.
Our Sales Engineers will be glad to consider your motor problems without obligation. Because of our tremendous backlog of existing designs most likely we can select the answer to your requirements immediately. If not, we are equipped and staffed to design to your specification.

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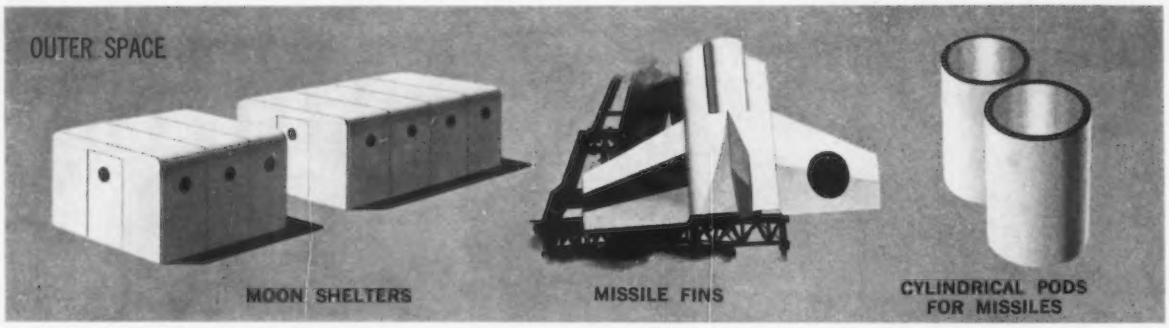
1960
1961



AIRCOMB® applications

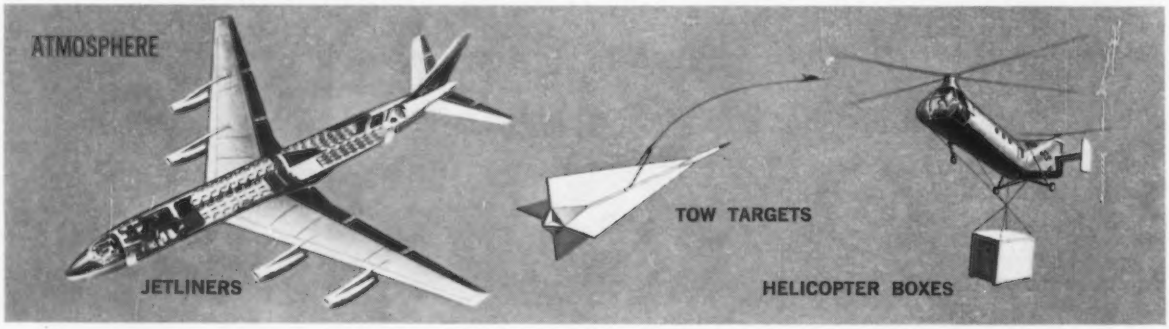
FROM SEA LEVEL TO DEEP SPACE

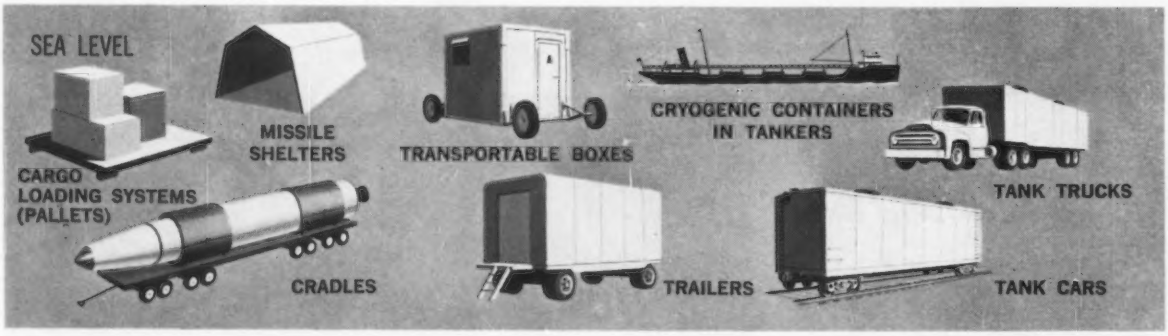
Makers of tanks for transportation of materials at cryogenic temperatures (approximately −300°F) have discovered that *Aircomb* can reduce wall thickness and weight more than 50% over present methods. Applications include tankers, tank cars, tank trucks and storage tanks. This Douglas product insulates against temperature changes — relative to thickness — better than any other known material and maintains its integrity in the process.

Another recent use of *Aircomb* is in piggy-back cylinders for outer space research. *Aircomb* cylinders may be produced with gun-barrel smooth interiors in diameters up to 66 inches and lengths to 20 feet.

The illustrations above and below show present and potential uses of this material.

To meet the specific needs of customers, Douglas will supply *Aircomb* core material... panels... partial products... products which incorporate customer-furnished equipment... or finished products.





WHAT AIRCOMB® IS: *Aircomb* is highly-uniform phenolic-impregnated Kraft honeycomb which can be bonded to an almost unlimited variety of laminating materials as thin as .005". It is the only material of its type guaranteed for quality, strength and compliance with government and military specifications.

NOTE: AIRCOMB is the only paper honeycomb product to comply with the following specifications: AMS3720 ... AMS3722 ... CAA Safety Reg Release 259 Para 2 (a) ... MIL-E-5272 (Fungus)

DOUGLAS

AIRCOMB®

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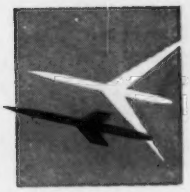
Data Capsule



SUMMARY OF MANAGEMENT TRENDS AND TECHNICAL DEVELOPMENTS IN THE AEROSPACE INDUSTRIES

MISSILES AND SPACE VEHICLES

Design

CLEVIS-TYPE JOINT was used in three-segment, conical solid propellant rocket motor, recently test-fired. Joint holds segments of motor together. This interchangeable device was developed at United Technology Corp. in cooperation with Pratt & Whitney Aircraft. Segmented approach offers advantages of easy handling.

MINUTEMAN FINENESS RATIO (radar cross-section of re-entry vehicle) makes it is more difficult to intercept than previous ICBM's.

NEW COMMUNICATION SYSTEM, still in experimental stage, may offer a virtually jam-proof link between Minuteman control centers. Radio waves from buried antennae are bent by refraction after reaching the surface. They then travel close to the ground until they reach the surface receiving-antennae. System would eliminate underground cables.

PILOT WARNING SIGNALS in Mercury are not yet considered completely fool-proof. These are red lights, sometimes coupled with warning buzzers. In the deployment of the main chute, it is still possible under certain circumstances to have no light and have a failure, red light and have proper function, or green light despite an actual streaming chute. Pilot must quickly check by window and rate of descent indicator.

Development

NASA'S SPACE TASK GROUP is now an autonomous field element of the space agency. It has management responsibility for Apollo and Mercury projects.

PROJECT ARENTS PAYLOADS are being developed by Convair (Astronautics) for launchings next year into 22,000-mi orbits. This "ARPA Environmental Test Satellite" program will determine effects of these altitudes on materials, components, and subsystems.

CHEMICAL WARFARE SD-2 DRONE is being developed by the Aeronautical Div., Aerojet-General Corp. Door on fuselage underside accommodates chemical, biological, surveillance sensor and control equipment.

MERCURY GLOBAL STATIONS have been completed and are undergoing "pre-mission checkout." Duties include tracking, telemetry, communications, command control, data reduction. Longest period in which astronaut will be out of voice contact with a ground station: 20 min. If Mercury spacecraft enters an unplanned orbital course, teamwork of astronaut and global network must work out time for firing retros. Navy support force would deploy in predicted landing area.

UNDERWATER TESTS at Navy's centrifuge are becoming more important since buoyancy partially simulates orbital weightlessness. Recently, Navy "frogmen" were completely submerged for 18 hr. They were spun on centrifuge to blackout both before and after immersion. Program aims at determining effects of weightlessness on "G" tolerances within a spacecraft during re-entry.

FIRST OGO SATELLITES will be developed for NASA by Space Technology Laboratories. Contract now being negotiated calls for three 1000 lb "standardized" Orbiting Geophysical Observatories capable of 50 different experiments.

GIANT LOAD CELLS capable of measuring 1,500,000 lb thrust have been delivered to Rocketdyne, which will use the instruments in testing the F-1 booster. Equipment was produced by Baldwin-Lima-Hamilton, which is now building a new facility for measuring load cells.

HOUND DOG air to surface missiles being used as take off power augmentors for mother ship. Takeoff roll reported "substantially reduced." Missile's fuel supply can be topped up from parent B-52G's supply.

SNAP 10 nuclear power system for space vehicles expected to generate 300 watts of electricity.

Production

SERGEANT is now moving into industrial production at Sperry Utah Engineering Laboratory. Previous R&D models were hand-made, piece-by-piece types.

DEFENSE EQUIPMENT PLANNING may be coordinated by a single manager. His centralized agency would have charge of production equipment facilities now operated by DOD. Single manager idea was recommended by the General Accounting Office in a report to the Pentagon.

HYDRAZINE production from cheap liquid ammonia by applying nuclear energy being studied in Aerojet Nucleonic Division reactor. Production at fraction of present cost held possible.

20-TON MACHINE will be built by General Electric to produce the airframe of the advanced-concept "STEPS" (Solar Thermionic Electric Power Source).

Procurement

THUNDERBIRD (Mk. 2 VERSION) is being procured by the British services from English Electric. This advanced ground-to-air missile employs constant wave radar in its guidance system.

NASA BUDGET is expected to be about $1.1-billion for Fiscal '62. This figure, approved by the Budget Bureau, includes $50-million supplementary appropriation for NASA active communications satellites.

AIRCRAFT

Design

ADVANCED HONEYCOMB PANEL is being incorporated in test sections of three B-70's. The 10 x 10 ft panel has a mild "Z" configuration.

ARRESTING SYSTEM for jet transports using a plastic-covered water basin has been proposed by Northrop Corp.

ELECTRA MODIFICATION PROGRAM has been officially approved by the FAA. Planes will return to normal operating speeds of 373 mph after additional propeller mounts are added, nacelle structure strengthened, and wing strength increased. Investigation concluded that if engine nacelle or powerplant were damaged, "whirl mode" (pitching force caused by propeller displacement) is not rapidly damped out. As whirl mode progresses, its frequency could approach natural frequency of wing. Resultant increasing oscillations could have caused wing structural failure in the two Electra accidents.

Development

B-70 MILESTONE was passed recently when 11,202 basic engineering drawings for first prototype were released to the factory. Drawings represent over 6,000,000 engineering manhours including almost 10,000 hr of wind tunnel testing. B-70 projects recently reinstated include: reference data system providing all-weather attitude and heading reference. (Sperry Gyroscope), and horizontal and vertical stabilizers (Chance Vought Aeronautics).

FIRST PUSH-BUTTON AUTOMATIC PILOT for jet transports has been certified by the FAA. Called the SP-40 (Sperry Phoenix), it is being delivered in volume for the Lockheed JetStar.

T64-4 TURBOPROP will begin nine-months of flight-testing this May in de Havilland's DHC-4 Caribou. Under development by General Electric since 1957, it is suited for fixed wing utility, VTOL, and STOL aircraft.

Production

MARTIN'S LAST AIRPLANE, a Navy P5M-2, has been delivered. Firm will now concentrate on missiles, electronics, nuclear energy, space exploration.

Procurement

SIKORSKY'S S-61L, new helicopter for airline use, has been ordered initially by Los Angeles Airways and Chicago Helicopter Airways for service this year. A twin-turbine, it can carry 28 passengers.

The Aerospace M·A·P

This capsule of developments and trends is part of Aircraft & Missiles' Marketing Assistance Program, a research service to aid companies in the aerospace market.

A reprint of this data can be obtained by writing on company letterhead to The Editor, AIRCRAFT & MISSILES, Chestnut & 56th Sts., Phila. 39, Pa.

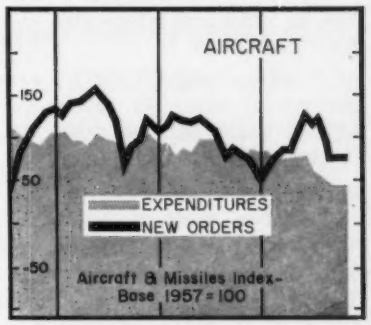
Army's Shopping List

The prospect of increased defense funds spells m-o-d-e-r-n-i-z-a-t-i-o-n to Army. If Army had a fairy-godmother in DOD who said, "buy what you want"; what would Army buy? In a Special Report . . . Army Tells Industry, Aircraft & Missiles revealed some of the details in December. Now a complete Army shopping list for 1961 is available. It should be a bonanza to marketing experts trying to strike up some business with this service. Here it is, with items listed in order of priority.

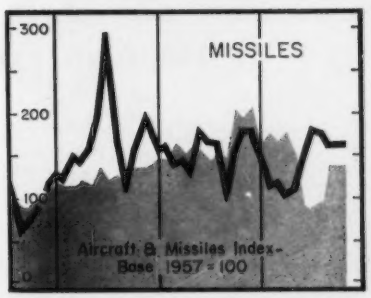
ITEMS IN ORDER OF PRIORITY	QUANTITY	COST $ MILLIONS
New rifle with NATO round	120,000	14.0
NATO round for new rifle + machine gun (1000 rounds)	200,000	18.4
New armored personnel carrier	600	17.7
New fully mobile division artillery howitzers	55	5.3
New extended range ammunition for artillery howitzers (rounds)	551,000	25.9
New fully mobile long range gun (175 mm)	115	16.8
Ammunition for new long range gun (175 mm) (rounds)	250,000	23.5
Main battle tank	300	45.0
Ammunition for new main battle tank (rounds)	59,400	11.0
New infrared fire control for main battle tank for night fighting capability	2,040	20.0
Mohawk battle field surveillance aircraft	8	4.7
New Iroquois transport + medical evacuation helicopter	62	20.2
All weather automatic instruments for Army aircraft	53	7.9
Battlefield medium troop and cargo transport helicopter	74	15.0
Expedite availability of Pershing	—	17.1
Expansion of Hawk missile deployment	—	8.8
Expedite availability of Redeye	1,200	7.8
Expansion of La Crosse deployment (battalion sets)	4	46.3
Expedite availability of Little John	600	4.8
Expedite availability of Sergeant	50	20.2
Expedite availability of Honest John, including warheads	701	17.5
Davy Crockett rockets	6,247	6.5
New anti-tank missile + launcher	4,233	7.2
Latest improvements for Nike-Hercules overseas air defense missile system	—	44.7
Goers-large capacity cross-country transport vehicles	300	7.0
New mobile light support weapon (81 mm)	60	2.4
Ammunition for the new mobile light support weapon	807,000	25.2
Caribou battlefield transport aircraft	36	21.3
New armored command and reconnaissance vehicle	250	8.4
New light combat recovery and repair vehicle	190	19.4
New light infantry shoulder-fired assault rocket	775,000	22.5
New amphibious Arctic personnel + cargo carrier	137	6.1
New mobile air defense fire direction system	—	40.7
New chemical rocket (115 mm) and multiple launchers	13,000	3.5
New combat surveillance drones	310	23.8
Radar flight-control systems for drones and aircraft	19	6.7
Division-Corps forward area communications	—	36.7
Seminole combat command-control airplane	19	2.9
Aerial Crane (helicopter)	6	12.5
New electronic counter-measures for jamming enemy artillery fuses	45	3.8
Chinook battlefield helicopter	6	9.0
New tank transporter	240	16.8
New over-the-beach combat transporter	534	25.3
New shoulder-fired grenade launchers	3,600	6.7
Forward area tactical vehicle FM command radio	3,331	21.7
Tactical generators for combat and missile units	4,671	5.6
New battlefield mine detecting and clearing devices	1,115	5.6
Field artillery fire-control instruments	3,400	3.8
Tactical wheeled vehicles from ¼ to 10 ton capacities	16,445	99.7
New 90 mm recoilless rifles	1,000	2.4
Ammunition for new 90 mm recoilless rifles (rounds)	280,000	16.8
Battlefield intelligence analyzer	—	18.5
Rolling fluid transporter	845	4.8
Ammunition for artillery weapons and chemical mines	335,000	22.3
TOTAL COST	—	$928.0

DEFENSE EXPENDITURES AND NEW ORDERS

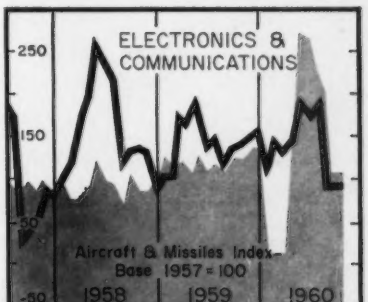
3 Months' Moving Average Index



Aircraft includes air-frames, engines armament, electronics, and other government furnished equipment. Also included: special tools, test equipment, and ground handling equipment.



Missiles graph includes complete missile systems—armament, launching, guidance, control, boosters, sustainers, propellants, special tools, and ground handling equipment.



Electronics and communications graph is related to the following equipment: radar, eletromagnetic equipment, computers, radiation airs, countermeasures, radiac and infrared, meteorological equipment, sonar, transmission or reception units, noise and interference detection devices, test equipment, spares, and related component equipment.

The Aerospace M-A-P

Business Moves

Radiation Inc. has changed the name of its subsidiary, Levinthal Electronic Products, Inc., to "Radiation at Stanford."

Zenith Plastics Co. has been made an operating division of Minnesota Mining and Manufacturing Co.

North American Aviation has changed the name of its Missile Div. to Space and Information Systems Div.

Chance Vought Corp. is now the official name for the former Chance Vought Aircraft Inc.

Vanguard Air and Marine Corp. has made an agreement with Seaflight Corp. whereby Vanguard's engineering staff is consolidated with Seaflight's development staff. The agreement provides that Vanguard will assist in completing the development of Seaflight's consumer seaplane.

Facilities

Sanders Associates, Inc., has transferred work on the Navy's Eagle target-seeking equipment to its new Advanced Systems Laboratories in Burlington, Mass.

General Instrument Corp. is beginning large-scale production of second and third generation transistors and other semiconductor devices at its new Hicksville, N. Y., plant.

American Laboratories Div., American Electronics Inc., is operating a new acoustic test facility for commercial testing of electronic components and sub-assemblies under actual acoustic conditions encountered in missiles and aircraft. It provides an overall sound pressure level of 160 db in a test area 1 ft by 1 ft by 3 ft.

Convair Div., General Dynamics Corp., is moving its Dynapak facility from Pomona to San Diego. Facility manufactures high-energy rate metal-forming machines and a line of advanced mechanical test equipment.

Litton Systems Inc. is developing and producing navigation and fire control computers in its new Computer Systems Lab, Woodland Hills, Calif.

Contracts

The Martin Co.—$76,921,772 for continued development of the Army's Pershing system.

General Electric — $34-million to the Ordnance Dept. for design and fabrication of advanced fire control systems for Navy's Polaris subs.

General Electric—$23,500,000 to the Defense Systems Dept. for guidance work on Air Force's Atlas.

Hughes Aircraft—$20,943,120 for four Army Missile Monitor operations central systems.

Bendix Corp.—$20-million to the Eclipse-Pioneer Div. for continued manufacture of the inertial guidance system for Pershing.

Sperry Utah Engineering Laboratory—$16.8-million for production of the Sergeant missile.

General Telephone & Electronics Corp. — $9-million from Convair for continued production of electronic defense system for B-58 Hustlers.

Bendix Aircraft — $6.4-million from Douglas Aircraft for transistorized autopilot flight controls for the Navy's A4D aircraft; $2.9-million from Boeing Airplane for similar systems for the 707 and 720.

Hughes Aircraft—$6.6-million for continued production of Polaris inertial guidance systems.

Lockheed Aircraft—$4,941,573 from the Navy to install Julie-Jezebel detection equipment on Neptune antisubmarine aircraft.

Aeronutronic Div., Ford Motor Co.—$3-million for continued R & D of Shillelagh weapons subsystems.

Northrop Corp. — $2,972,578 from the Army to produce 770 RP76-3 target missiles.

Convair—$1.9-million to Astronautics Div. for three experimental Arents satellite payloads to be placed in 22,000 mile orbits next year by Centaur.

THE CIVIL AIRCRAFT MARKET

AIRCRAFT SHIPMENTS

	Units		Value (000,000)	
Month	1960	1959	1960	1959
January	747	665	$96	$50
February	855	619	113	50
March	867	736	90	34
April	768	745	127	68
May	802	759	131	81
June	694	779	110	65
July	539	630	120	88
August	420	647	98	95
September	427	432	108	76
October	618	739	81	104
November	....	705	....	77
December	....	786	....	112
Year	....	8,242	....	$900
10 Mos.	6,737	6,751	$1,070	$711

PISTON ENGINE SHIPMENTS

	Units		Value (000,000)	
Month	1960	1959	1960	1959
January	1,025	873	$2.5	$2.6
February	1,039	954	2.6	2.7
March	1,141	921	3.2	2.6
April	1,064	947	2.5	2.7
May	894	921	2.3	2.3
June	772	979	1.8	2.7
July	579	844	1.7	2.0
August	873	747	2.3	1.7
September	864	804	2.3	2.2
October	862	1,051	2.4	3.9
November	....	1,060	....	4.3
December	....	1,051	....	3.6
Year	....	$11,152	....	$33.4
10 Mos.	9,113	$7,990	$23.5	$25.5

NET SALES (In Millions)

Products and Type of Customer	Nine Months 1960	Nine Months 1959
Complete Aircraft and Parts		
For U. S. Military Customers	$2,527	$3,075
For Other Customers	1,344	965
Total—Aircraft and Parts	$3,871	$4,040
Aircraft Engines and Parts		
For U. S. Military Customers	$663	$954
For Other Customers	317	291
Total—Engines and Parts	$980	$1,245
Aircraft Propellers and Parts		
For U. S. Military Customers	$55	$41
For Other Customers	20	30
Total—Propellers and Parts	$75	$71
Total—U. S. Military Customers	$3,245	$4,070
Total—Other Customers	$1,681	$1,286
Other Products and Services	$3,235	$2,871
Total—All Products	$8,161	$8,227

BACKLOG OF ORDERS (In Millions)

Products and Type of Customer	September 30 1960	September 30 1959
Complete Aircraft and Parts		
For U. S. Military Customers	$4,384	$4,635
For Other Customers	1,807	2,383
Total—Aircraft and Parts	$6,191	$7,018
Aircraft Engines and Parts		
For U. S. Military Customers	$1,278	$1,151
For Other Customers	322	437
Total—Engines and Parts	$1,600	$1,588
Aircraft Propellers and Parts		
For U. S. Military Customers	$52	$56
For Other Customers	9	12
Total—Propellers and Parts	$61	$68
Total—U. S. Military Customers	$5,714	$5,842
Total—Other Customers	$2,138	$2,832
Other Products and Services	$4,611	$3,384
Total—All Products	$12,463	$12,058

Plastic Polaris Planned

Second generation A-2 vehicle uses filament-wound upper stage
Silica-filled rubber liner protects case from 5000°F by ablation;
Super Polaris may have epoxy-glass first stage and graphite nozzles

By John P. Kushnerick

Polaris is on the way to becoming a non-metallic missile. The second generation A-2 uses an epoxy-reinforced, filament-wound second stage. In A-3 Super Polaris Navy may well go to filament winding for both first and second stages.

Range of the A-2 has been boosted to 1500 mi. Navy says about ½ to ⅔ of the range increase comes from Aerojet's improved first stage. It has been lengthened some 30 in. and reduced in inert weight by "several hundred" pounds. The remainder of the extra range is attributed to the plastic upper stage, designed and developed by Hercules Powder Co.

The A-3 will have a range of about 2500 mi. Aerojet will probably use its own filament wound cases in the first stage, and Hercules will improve its Spiralloy second stage. The swing to non-metallics is evident even in the rocket nozzle which is made from graphite.

Aerojet, late last year installed a filament winding machine to make prototype cases for A-3's first stage. Using E-Glass and Shell's Epon 828 resin, cases 160 x 54 in. are being wound in 8 to 10 hr. Winding is done with length axis in the vertical position. A salt-soluble plaster is used as the winding mandrel. Cure is critical and is carried out at 200°F for about 8 to 12 hr. Strength of case compares favorably to present steel cases, but no firings have been performed with this plastic first stage. All strength data is based on tensile and burst testing.

Birth of Plastic Case—The second stage structure for A-2 has its roots in a Navy sounding rocket called Deacon. In 1958 Young Development Lab, now a division of Hercules, and Allegany Ballistics Lab, operated by Hercules for Navy, fabricated a plastic motor by filament winding the case directly over a Deacon propellant grain. Then started an improvement proc-

GREATER LENGTH of first stage in Polaris A-2 is evident. Aerojet says case is "some 30-in. longer." Diameter remains the same. This is first photo which shows Polaris dimensions by having a man by which to scale. Polyurethane/perchlorate composite with aluminum additive is used as propellant.

PLASTIC POLARIS . . .

Ovaloid geometry of second-stage end closure makes all stresses longitudinal in filament windings

ess through Nike Ajax, Terrier, Vanguard, and Altair that has culminated in the plastic Polaris.

Performance increase in the A-2 second stage comes directly from:

- Near optimum use of filament windings to produce a light weight case.
- An improved double-base propellant with a specific impulse higher than any now in use.

Hercules has long been identified with ballistite propellants—nitrocellulose and nitroglycerine combination. They have not deviated in Polaris, but, the double base system uses a hot binder and has been reportedly modified with powdered metallics to boost performance at least 5 per cent over Altair's 256 sec Isp.

A filled rubber liner insulates the plastic motor from the 5000°F heat of the burning propellant. The liner is Hycar 1052, a silica-filled, Buna N rubber that functions by the ablation process. B. F. Goodrich is the manufacturer. Nearly 25 per cent of the motor's inert weight is taken up by the liner. But, since the resin systems loses strength rapidly above 200°F the liner cannot be skimped on or eliminated. The case must be kept cool. Liner improvement is an area that could considerably increase Polaris range by driving up the mass ratio. It would reduce inert weight and allow a greater portion of the total mass to be constituted of propellant.

Mass Ratio—The significance of high mass ratio is great. A rule of thumb in the current state of propulsion art is that it takes 60 lb of propellant to orbit one pound of payload. An increase of one point in mass fraction can increase payload by 22 lb. A similar one point boost in specific impulse will increase payload only 5 lb.

Using Spiralloy, to get near optimum strength of individual fibers in filament winding, Hercules hit a mass fraction of 0.92 with the Altair and 0.93 with Scout third stage, Antares. Polaris does not approach this, it is about 25 per cent heavier than would be an Antares scaled up to Polaris' 54-in. O. D. and 80-in. length. Why? Certain compromises in the Spiralloy concept have been necessary in Polaris. The process is ideally suited to pressure vessels with polar openings, i.e., openings whose centers lie on the longitudinal axis of the vessel. Polaris has four non-polar openings for nozzles, and several others for thrust termination etc. Since jetavators have been eliminated in the advanced Polaris, devices for actuating the gimballed nozzles must also be accommodated.

Spiralloy Case—There are two important concepts embodied in Spiralloy.

- Fiber orientation
- Geometry of end closure

The process was devised as a means of winding cases with integral end closures and integral bosses at the polar openings. A continuous filament is first wound in a low angle helix for carrying longitudinal stresses in the vessel and bonding in the bosses. Circular windings are then applied over the cylindrical portion of the vessel to carry the girth loading. There are no circular windings on the end closures. The process has the ability to lay one filament immediately adjacent to another. Gaps and overlaps are held to a minimum. This results in even resin content and a sound structure. Optimum resin content is 16 to 20 per cent by weight.

The end-closure geometry is called "ovaloid." It assures that all stress in the end closure is transmitted through the longitudinal direction of the fibers.

Hercules recognized early in its studies that the structures and stress formulas which applied to homogeneous materials like sheet metal did not necessarily apply in the new filament wound structures. The hemispherical end closure was good for metals, but with filaments that have unidirectional strength properties it added extra weight for any desired strength.

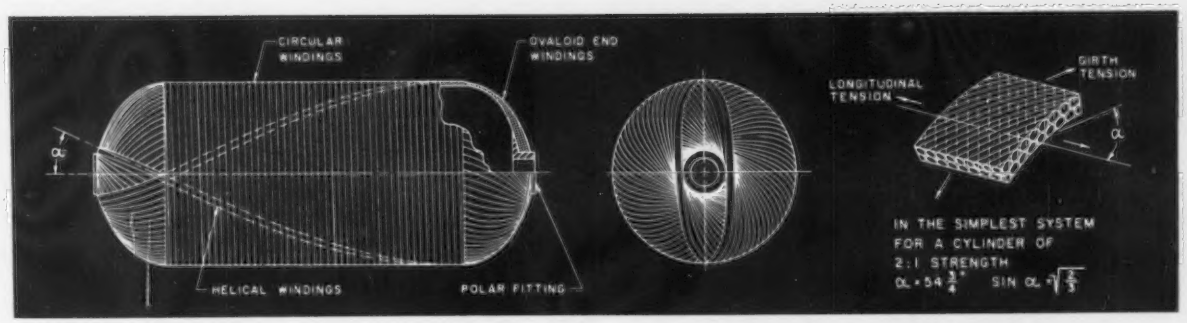
The ovaloid is difficult to derive mathematically, so it was done experimentally. Fibers were strung loosely "maypole style" to a movable ring, one end of fiber on the pole ring and the other a large base ring. The pole was removed and an inflatable membrane, balloon, was inserted and inflated. The pressure was contained by the filaments. Observing the profile assumed by the membrane led to the ovaloid configuration. The exact geometry varies with the angle of the helix windings. Analog techniques are now well developed for determining best profile for each winding pattern.

Hercules has a letter of intent from Lockheed worth $17 million for production of the A-2 Polaris motors. About 10 per cent, or less, of this will be for the plastic cases. Make or buy decisions have not been finalized. But, Hercules is sure it will not do all of the case fabrication. It will be spread out over other qualified Spiralloy producers.

Polaris Details—Technique developed by Hercules starts with fabrication of large plaster mandrels. A nearly lost art of plastic splining is being rejuvenated in fabrication of the mandrels.

Dimensional stability of the plaster molds has been excellent. When the plaster dries, the preshaped, filled-rubber liner is slipped over the mold and the assembly is ready to receive the filament wrap.

It has not been possible to wrap filaments continuously around the many nonpolar fittings in the aft end closure. Instead, metal bosses are accurately positioned and wrapped into the structure together with doublers of glass-cloth-reinforced epoxy. In a subsequent operation windings are cut out of the I.D. of the bosses. It is the doubler and metallic inserts that make this



FILAMENT WINDING TECHNIQUE for 2nd stage Polaris A-2 evolved from this ideal Spiralloy design. However, fact that Polaris has four non-polar openings for nozzle inserts and large phenolic ring (Raybestos RPD-150) for thrust termination has led to compromise and increased weight. Polaris propellant is nitroglycerine/nitrocellulose double-base combination with hot binder and metallic additive. Specific impulse is higher than any other solid in use. Steering is effected by hot-gas-actuated swivel nozzles.

motor case some 25 per cent heavier than an ideal Spiralloy case of equal size.

There are several other ports and attachments, but the major ones accommodate the Hercules designed nozzles.

Nozzles are conical, movable and uncooled. They are lined with graphite to fight the erroding forces of the rocket exhaust. Pyrolitic graphite has been experimented with but has not been incorporated into the design. Nozzle optimization will be the next step in increasing Polaris range further. Hercules has experimented with several means of cooling the nozzles. This is imperative if propellants are upped much in total and specific impulse. Several approaches are claimed as "promising" by Dr. L. G. Bonner, director of development at Hercules. Bonner also states that various nozzle shapes will be experimented with. Shorter nozzles would allow a longer rocket motor for the length-limited Polaris, but would result in lower specific-impulse. Longer nozzles would allow greater impulse but would result in less propellant charge.

Materials & Processes—Winding of the Polaris cases is done on a conventional lathe-type apparatus. Reciprocating, carriages deliver the filaments in their proper pattern. Carriages are timed by digital gearing.

Winding speed and filament tension are extremely important. At 8 feet per sec, a common winding speed, several hundred pounds of filament are delivered in an hour.

Both wet and dry filaments have been wound. But wet windings result in the more trouble free process. The filament is passed through a resin bath before it is fed onto the mandrel. Sufficient tension is applied to the filament only to keep it straight and deposited in an orderly fashion.

Hercules uses 12 end roving as a filament in Polaris. It is Owens Corning E-Glass with an 801 finish and an A-1100 silicone coupling.

There has been a great deal of discussion in filament winding circles about prestressing the filaments to give the final case greater strength. But Richard Young, father of Spiralloy, feels this is not feasible. "There is no member against which the preloading can be maintained. As soon as the mandrel is removed the filaments lose all of the prestressing." The rovings first of all will tolerate only a ten pound pull. Using a safety margin would reduce this figure to six pounds. This value is not significant. Even if stronger rovings were used, and greater tension applied, the limited resin content (16 to 20 per cent) would not hold the prestress after the mandrel was removed.

Resin system is basically Shell's Epon 828 with CL curing agent.

So-called dry winding would use preimpregnated filament (B-staged) that would be heated to give it flexibility before winding. Young feels this technique has many inherent problems.

When the case is completely wound it is cured under lamps or in an oven. Various temperature-time cycles are used. Long time cure at temperatures as low as 200°F have been satisfactory.

The plaster mandrel is partly water soluble and is removed by softening and chipping after the cure.

Testing—All cases are hydrostatically tested to 80 per cent of operational pressure. One out of every case lot is tested to destruction. Burst pressures have been rather consistent on pre-Polaris cases.

Developed at ABL the new second stage will be produced at Hercules ABL and assembled at Bacchus, Utah. These case-bonded double-base propellant units are X-rayed for voids and cracks which might allow hot gases to burn through the ablative liner and contact the case. This could result in destructive failure in operation, and is a critical test parameter.

Several scale model Polaris units have been fired in a vacuum simulating actual light off at altitude.

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Titan . . . The Aluminum Giant

Fuel and oxidizer tanks made of 2014 alloy;
New welding technique gives joint-strength of 60,000 psi;
Cryogenic tanks use hoop reinforcements

By Philip Geddes

Titan was designed to a specification that called for a stiff structure. Martin Co. designers used fresh thinking and were able to discard conventional riveted skin, and stringer barrel sections and produce successful all welded monocoque structures.

Key to success was a new technique for welding 2014 aluminum alloy sheets. Strength of welds is approx. 55,000 to 60,000 psi. Parent metal strength is only 40,000 psi. Welds were problematic early in the program, but rework has now been cut to less than 1 percent.

Making The Shape—The large missile is essentially a series of joined cylindrical tank sections. Contour forming is therefore confined largely to the tank ends. Careful design has reduced the number of end closure shapes to four—two dome shapes, and two cone shapes

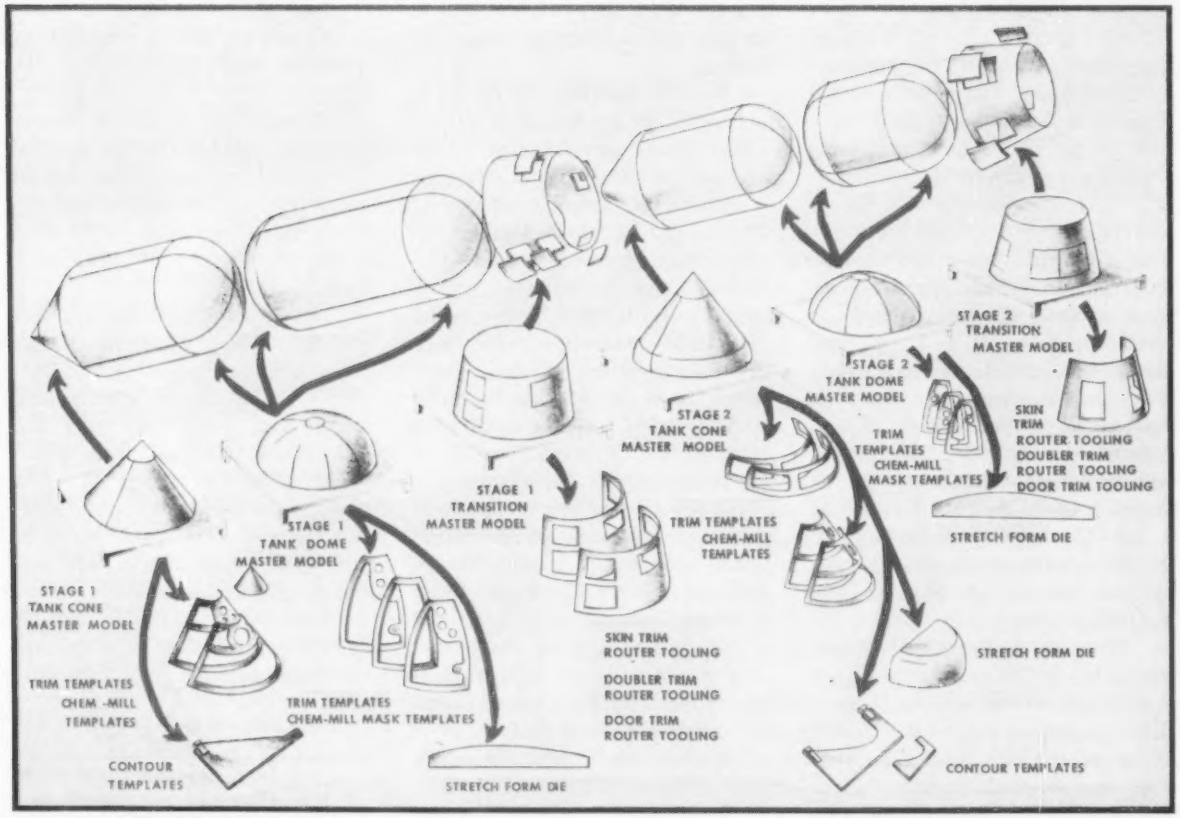
STAGE 2 TRANSITION MASTER MODEL
STAGE 2 TANK DOME MASTER MODEL
STAGE 2 TANK CONE MASTER MODEL
TRIM TEMPLATES CHEM-MILL MASK TEMPLATES
SKIN TRIM ROUTER TOOLING
DOUBLER TRIM ROUTER TOOLING
DOOR TRIM TOOLING
STRETCH FORM DIE
STAGE 1 TRANSITION MASTER MODEL
TRIM TEMPLATES CHEM-MILL TEMPLATES
STAGE 1 TANK DOME MASTER MODEL
STAGE 1 TANK CONE MASTER MODEL
SKIN TRIM ROUTER TOOLING
DOUBLER TRIM ROUTER TOOLING
DOOR TRIM ROUTER TOOLING
STRETCH FORM DIE
TRIM TEMPLATES CHEM-MILL TEMPLATES
TRIM TEMPLATES CHEM-MILL MASK TEMPLATES
CONTOUR TEMPLATES
STRETCH FORM DIE
CONTOUR TEMPLATES

FIG. 1. MASTER SHAPES and templates are shown for Titan tanks. Tank material is essentially 2014 aluminum alloy. Each first-stage barrel consists of 12 panels.

(Fig. 1). Titan II will benefit in manufacturing simplicity by being of the same diameter in both stages, namely ten feet.

Flat sheets of 2014 aluminum alloy, extruded with integral stringers, are received from the mill in the T4-semi hard condition. Twelve such sheets are required for building the cylindrical sections of the two tanks in the first stage.

The aluminum sheets for the second stage differ in that they consist of T-6 rolled monocoque skin. Three such panels comprise each second-stage tank.

Weight controls dictate that each panel be milled down to remove extrusion tolerances. Obviously, depth control of chemical milling which follows machine milling must also lean on tight starting dimensions. A single Giddings and Lewis magnetic tape controlled mill with a double cutter, mills every panel going into Titan tanks. The panels are milled flush on one side and then reversed for cleanup machining between the T-section stringers. Skin thickness of the finished panels is 0.107, ±0.007 in.

Once machined, the tank panels are stretch formed over kirksite dies. Titan II will only need one set of such dies in place of the two sets in use with Titan I. During the 2 per cent stretch, the accurately dimensioned sheets have to be restrained on the sides to prevent hour glassing. Panel stretching is accomplished on a specially designed Hufford biaxial stretch press of some 1400 ton capacity. Heat treat to the T6-hard condition follows.

"Orange Peel" Domes — The process Martin adopted for making the tank domes in stretch formed orange peel sections, then welding, was necessary for two reasons.

- Large close tolerance sheets were not available from the mill.
- No large forming or spinning equipment was available.

Late in the program, a reduction in the number of segments used has been possible and some formed end caps complete with formed-in outlets have been introduced. In this way the weld footage is reduced. Before welding, segmented domes are trimmed to size in an elaborate trim fixture. The segments are held hydraulically against an accurate contour while twin adjustable routing heads, working in opposite directions, cut off excess metal along the two long sides. Dome thickness is 0.100 in.

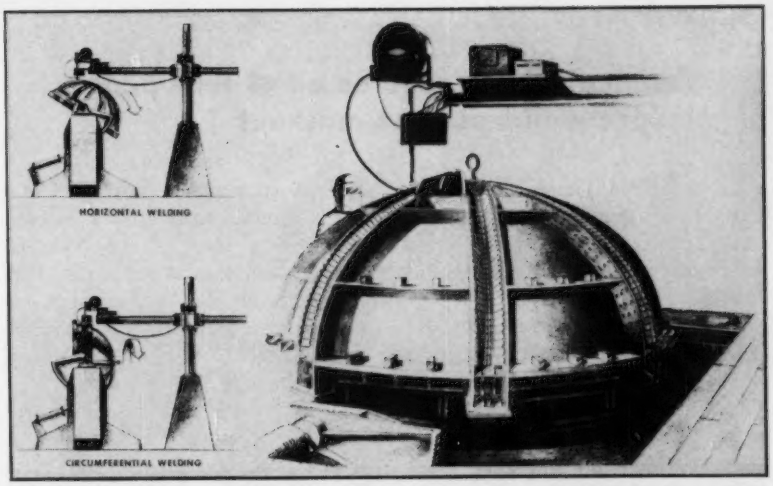

FIG. 2. DOME WELD AND TRIM fixture can be tilted for welding individual "orange peels" on Titan tanks, and rotated for circumferential welding and trimming.

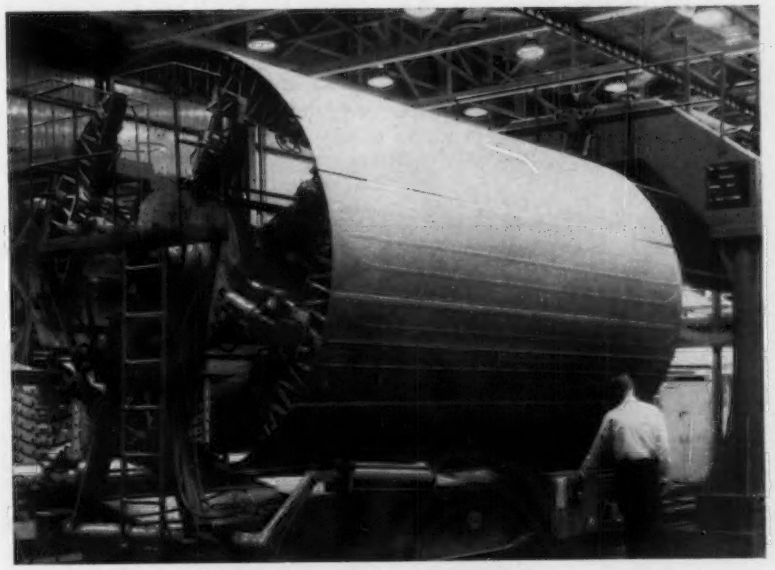

FIG. 3. FIRST STAGE barrel panels are assembled in this welding fixture. After positioning the panels, entire fixture moves into structure at right. 12 panels are automatically welded by a fixed head to complete the barrel.

Chemical Milling — Chemical milling is used quite extensively in Titan tanks. Early Titans were not chem milled but the weight saving possibilities could not be overlooked in an eventual weight optimization program. All 48 panels

Chemical milling used on all 48 tank panels, Neoprene film used as maskant

comprising the Titan's tanks, now carry some degree of chemical milling. The—'a pound of weight saved means an extra mile range' is well heeded.

The neoprene film used for masking in the chem mill process is applied to a minimum thickness of 0.006 in. and cured in a 225°F oven. Most masking templates are made of epoxy bound glass cloth contoured on the same master shape used for making the stretch press dies and trim templates (Fig. 1).

Welding — Optimum tensile strength in the 2014 alloy is achieved by welding in specially designed fixtures with high heat dispersal away from the work area. Welds on the tanks are generally made on butt joints and are a blend of parent and fill metal. Completed welds are not dressed except where mating takes place against a welded section.

Each butt joint to be welded is backed up with an aluminum chill bar. A steel plate undercut 0.050 in. is inserted in a groove beneath the puddle area of the weld to prevent adhesion to the tooling and ensure complete penetration. A series of aluminum fingers along the butt joint hold the separate sheets tightly together.

The dome end segments are joined in a versatile weld and trim fixture gimballed in two planes (Fig. 2). In this way, all major welds on the ends can be performed on one fixture. The welding head (on a boom) is positioned, then the fixture turntable tilted about its horizontal axis to make a weld from apex to base. Tilt speed can be adjusted to suit the operation. The turntable is then rotated to the next segment joint and the process repeated.

After welding the segments together, the turntable is rotated 360 deg about its vertical axis while a built-in router trims off excess metal from the base. A circular extruded frame member is then attached to the base of the dome and welded into position. For this the table is tilted 90 deg and rotated 360 deg.

Ingenuity is evident in the weld fixture for manufacturing the tank barrels. This fixture consists of a travelling bed mounted on fixed slides (Fig. 3). The bed moves into a fixed weld bridge carrying a moving weld head and associated controls. As stated previously, a first stage tank is made up of 12 formed panel sections. A set of three panels is positioned on the weld fixture and held in place on male paddles by pneumatic clamps. Clamps grip the T-section stringers integral with the skin. Once positioned the three panels are moved under the welding bridge. The overhead then moves along the stationary set of panels welding one seam as it goes. The complete assembly is then withdrawn from under the welding bridge, the panel assembly rotated to the next weld seam and the welding process repeated.

After four quarter sections have been processed as described, the four sections are welded together in the same fixture using the same method as for each sub section. Work on the barrel weld fixture is not complete until the barrel ends are trimmed square by two electrical cutting heads.

Some internal structure exists inside of the cryrogenic tanks on both stages of the Titan.

To help support the large racking loads imposed by the thousands of gallons of liquid oxygen carried in Titan, a series of light hoops are assembled inside the lox tank barrel sections. These hoops of T-section extruded aluminum fit onto light slotted clips riveted to the integral tank skin stiffeners (Fig. 4). Simple pins riding in the clip slots hold the frames loosely in position.

Each tank barrel with its two end domes is assembled and welded on an automatic rotating fixture. (Fig. 5). This fixture consists of a bed on either end of which are two chucks. Between the chucks in the middle of the bed are two roller rings capable of receiving a tank barrel section. The end domes are

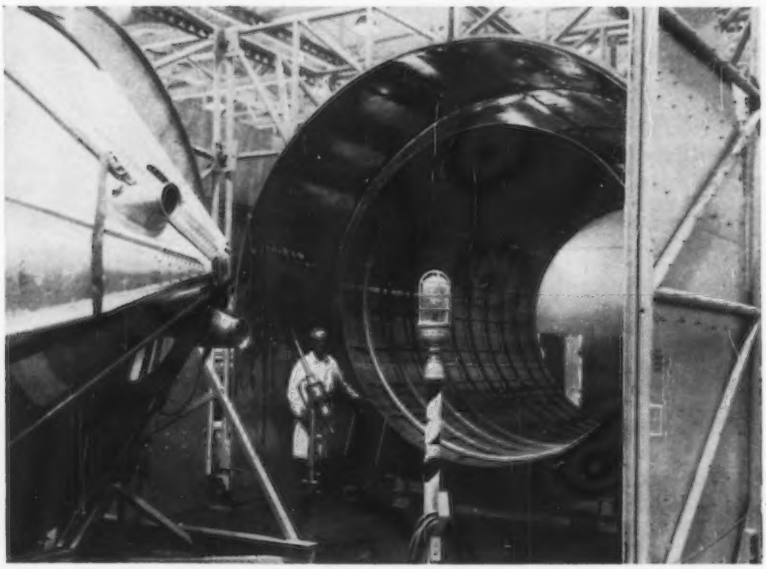

FIG. 4. CRYOGENIC TANKS are reinforced with T-section hoops. Technician is shown with X-ray equipment used to detect flaws. Conical section at left is used as end closure on aft end of several tanks.

placed in the chucks and a barrel in the roller rings. The major fixture segments are rolled together forming butt joints for welding. The same heat isolation practices employed elsewhere must be used in welding the major assemblies. The welding head for the fixture is positioned and then the whole barrel assembly is rotated to make one continuous seam weld at a time on each end. Concentricity is held to 0.032 in.

Tank Inspection — Visual, and dye penetrant weld inspection techniques are used on all subassembly welds. The barrel and dome welds are X-rayed for cracks, porosity, inclusions and incomplete fusion. The checking films are taken by placing the unexposed film cassettes on the outside skin and the X-ray source on the inside. After X-ray the tanks are hydrostatically tested at 25 to 50 psig depending on the size of the tank.

Tests are monitored through closed circuit TV as a safety precaution. After tanks are tested and calibrated they are placed in a cleaning cell for alkaline spray cleaning. Following cleaning the tanks are rinsed then de-oxidized by the same automatic spray system. A flash film of Iridite is applied to the outside and a chromate film to the inside for corrosion protection. Hot air blasts the tanks dry before they are purged with dry nitrogen.

Intersections And Assembly — The engine fairings, between tank sections, and interstage sections are of conventional, magnesium skin-and-stringer aircraft construction. These six barrel assemblies, three per stage, are manufactured in the Martin company's Baltimore plant. Skin thickness is approximately 0.040 in. No chemical milling is used. Of vital importance in the final assembly procedure is the alignment of each tank and transition piece before splicing. The horizontal splice fixtures carry movable end plates and subheaders (Fig. 6). The subheaders move on ball bearing raceways which allow header movement along the base of the fixture for moving sections together. Fixture alignment and parallel position of the end plates and headers is maintained by an optical line of sight in the fixture base and two auxiliary lines of sight at the vertical and horizontal center lines. The engine mount attaching points are controlled through master gages on an end plate. Assembly of the first and second stages of the missile is done on parallel production lines. Stages are not mated until they reach one of the cells in the Denver test facility. Test firing follows.

Each one hour on the test stand stands for about twenty hours reduction time on an IBM 704.

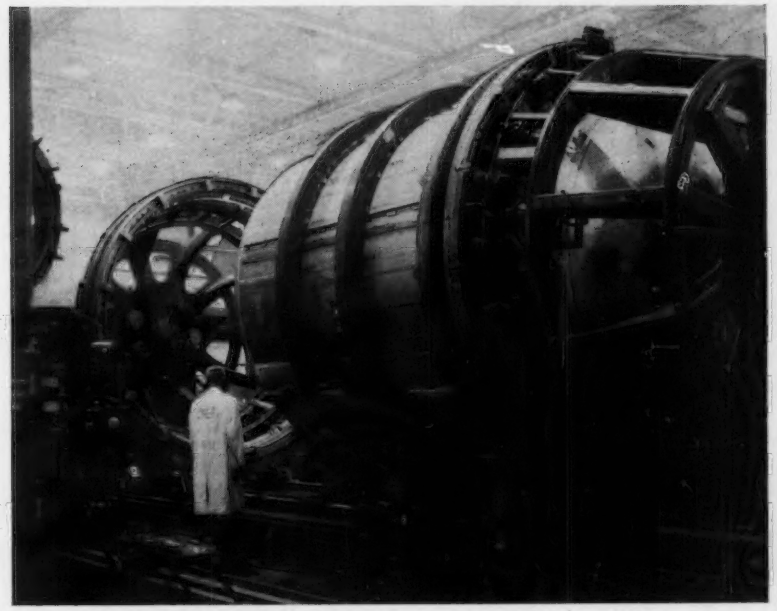

FIG. 5. MATING FIXTURE is used to join barrel assemblies with tank domes. Welding head is accurately fixed in position. Then, entire tank is rotated to effect circumferential weld.

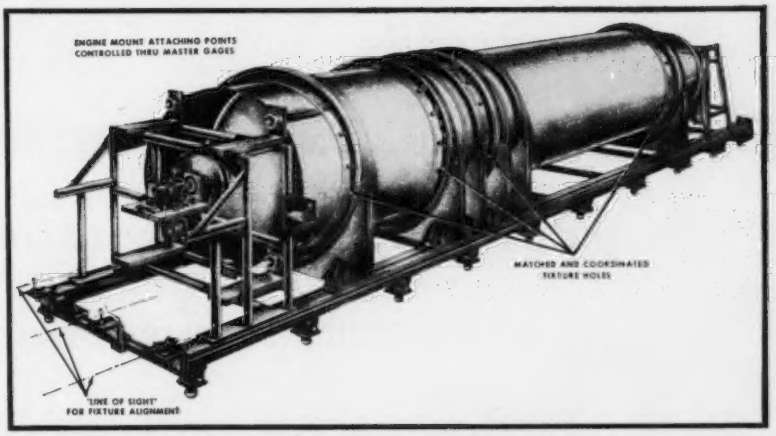

FIG. 6. SPLICING TITAN STAGES is done in this horizontal fixture. Alignment accuracy is vital. Optical methods are used. Engine attach points are controlled by master gages on the end plate.

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and on new, advanced contributions to the Space Age.
they find a sense of being, of doing, of accomplishing.

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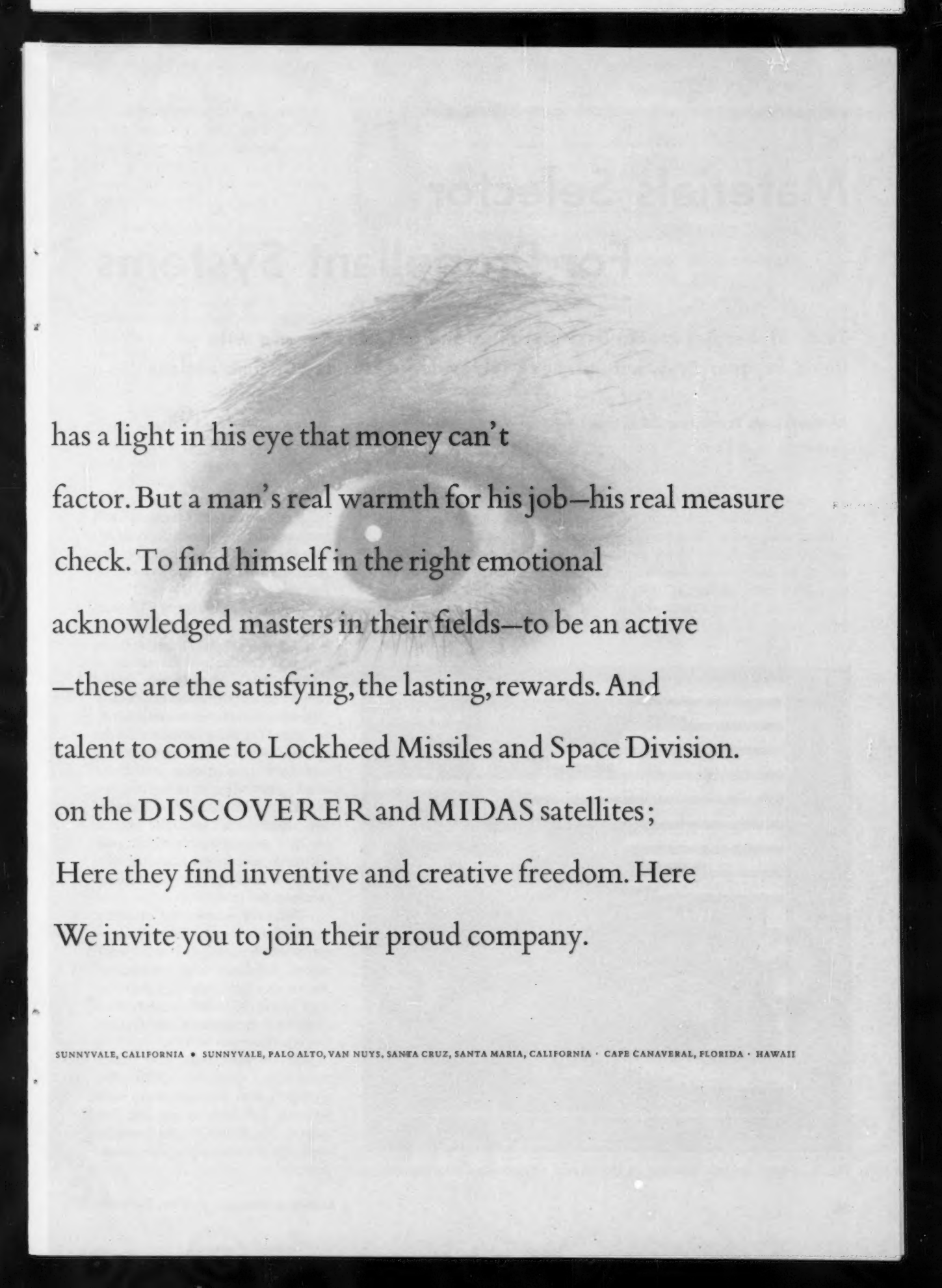

has a light in his eye that money can't
factor. But a man's real warmth for his job—his real measure
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acknowledged masters in their fields—to be an active
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talent to come to Lockheed Missiles and Space Division.
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Materials Selector For Propellant Systems

Tests at Aerojet reveal best metallics and organics for use with liquid oxygen/ RP-1, and nitrogen tetroxide/ Aerozine-50 combinations

By Eugene M. Tomlinson, Development Engineer
Aerojet General Corp.

Selection of materials for aerospace vehicles is an important and ever-changing need. Requirements are advancing faster than technology, so the problem is becoming more and more difficult.

The effect of propellants on material properties is a prime concern. Fabrication of parts from very desirable materials is a secondary concern.

The data that follows concerns materials selected by Aerojet-General for service in liquid oxygen/ RP-1, and nitrogen tetroxide/Aerozine-50 propellant. Only the materials found satisfactory for general use are mentioned. Materials that were rejected as wholly unsatisfactory are not discussed. (Ed. Note: Aerozine-50 is a hydrazine-base fuel.)

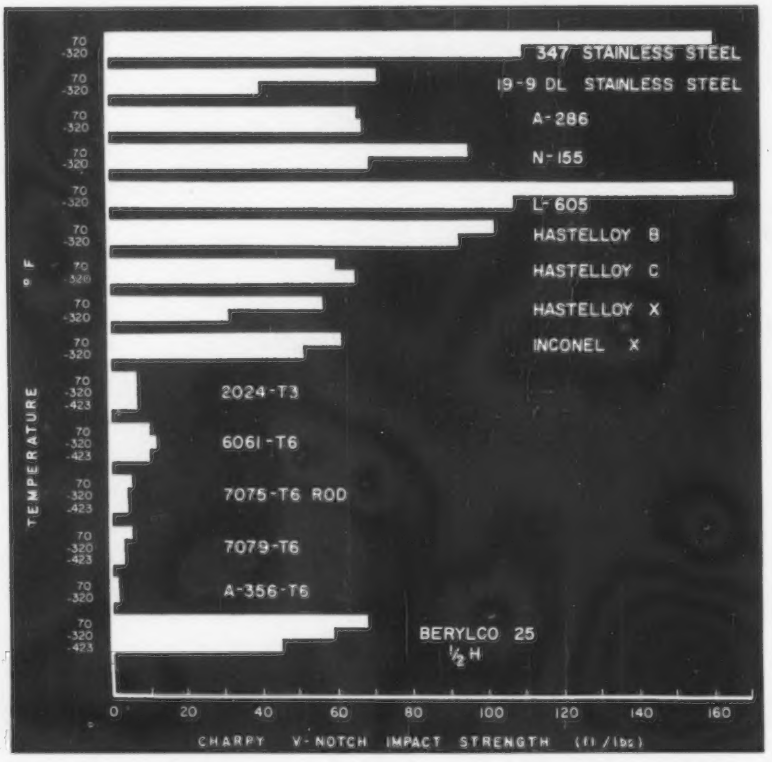

Fig. 1. Metal Impact Strength at Room and Cryogenic Temperatures.

Metals For Oxygen — Prime considerations in selection of metals for use at cryogenic temperatures are good ductility and resistance to thermal shock. Stress levels, fabrication characteristics, and corrosion resistance should also be considered.

The 300 series stainless steels are used where design requirements accommodate a thicker section to offset lower strength properties.

Where high strength is a requisite, hardenable austenitic alloys (A-286) and hardenable nickel base alloys are acceptable. However, difficulty in welding of thick sections creates a use limitation.

The semi-austenitic stainless steels offer the advantages of highest strength combined with corrosion resistance and weldability. As an example: AM-350 stainless steel in the SCT 1050 heat treated conditions has proved satisfactory for liquid oxygen service.

Of the aluminum base materials, 7075 - T6 and 2024 - T4 wrought alloys are used where high strength and low weight are required. The 6061-T6 aluminum is used for pressure tight case components.

Impact strength and tensile elongation data for some of the above mentioned alloys are shown in Fig. 1 and Fig. 2. Fig. 3 compares the materials on a yield strength-density ratio basis.

Nonmetallics For Oxygen—Impact sensitivity and proportional elastic limit at cryogenic temperatures are the special criteria for nonmetallics. There have been no major problems in service with most of the original selections of nonmetallics. The most suitable nonmetallics, by category, for use with LO_2 follow:

(1) Elastomers: Certain chloroprene and buna-N compounds are successful in gaseous oxygen as static and dynamic seals at ambient temperature. They also serve well as static seals in liquid oxygen. Fluorosilicone (LS-53 Dow-Corning Corp.) is another elastomer that has been used with a degree of success.

(2) Lubricants: Halogenated paraffin oils with pour points as low as –100°F can be used in assembly of static O-ring seals in liquid oxygen systems. These oils are not appropriate for lubrication of aluminum in a high shear application. Thread anti-seize sealants of graphite in chlorinated organic carrier have been found suitable for use in liquid oxygen.

(3) Thermoplastics: Materials selected for static seals and gaskets in liquid oxygen are perfluorinated polymer (Teflon) and orientated film of polyethylene teraphthalate (Mylar). Both are products of E. I. du Pont. For dynamic applications, a screening test reduced the initial selections to polychlorotrifluoroethylene (Fluorothene FYTD, Fluorothene FYTS, from Bakelite Div. of Union Carbon and Carbide; Kel F-240, Kel F-300, and Kel F-500 from Minnesota Mining and Mfg. Co.). Extensive physical and mechanical property testing revealed Kel-F-300 to be the better material. Compression molding of Kel-F-300 in sheets up to ½ in. thick followed by a rapid cold water quench and a heat treatment has been found to yield the best combination of properties.

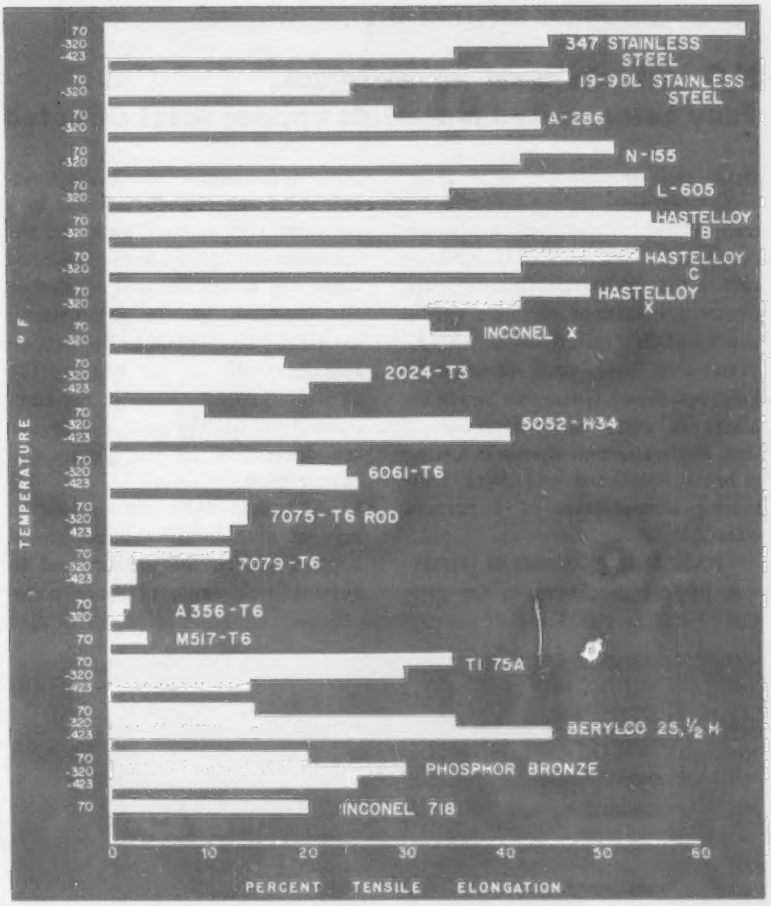

Fig. 2. Percent Tensile Elongation for Metals at Room and Cryogenic Temperatures.

"Filled Teflon," i. e., using glass fibers to reduce cold flow, is superior to Kel-F-300 for most cryogenic static seals.

Metals For RP-1—The metals appropriate for use in liquid oxygen service are normally usable in RP-1. The 300 series stainless steels, cast and wrought aluminum base alloys, A-356, 6061, and 7075 are generally recommended.

Nonmetallics For RP-1—Materials used in conventional jet engine service are useful in RP-1 service. Nylon per MIL-P-17091-B and Kel F-300 are suitable for most dynamic applications. Teflon is suitable for gaskets and static seals. Buna-N elastomers per MIL-P-5315 are suitable and find use in both static and dynamic applications. The RP-1 will lubricate dynamic seals during operation. Liquid oxygen thread anti-seize sealant can be used for low pressure, but only for lubrication of the threads to allow for disassembly. Where high pressure sealing is required white lead is recommended.

Exhaust Gas System—The criteria for metals in hot gas systems are high temperature, strength, and ductility. Cast 347, Investment Cast N-155, A-286, Haynes Stellite 21 (a cobalt-base alloy), Udimet 500, and Cr-Ni-B spray for bearings have been found to be suitable for use in hot gas systems. Cadillac Motor Car Div. Gasket Cement and Fel-Pro No. c6 (Felt Products Mfg. Co.) nut and bolt anti-seize compound per MIL-A-907 are satisfactory and find use in high temperature service.

Metals for N_2O_4/Aerozine-50—Selection of metals for use in

N_2O_4 attacks most nonmetallics, Fully halogenated materials appear least affected

N_2O_4 and Aerozine-50 is in progress. Corrosion testing under static and dynamic conditions are being conducted. Water, either from moisture in the air or from flushing, produces a corrosive medium (nitric acid) when mixed with N_2O_4. Water-free N_2O_4 and Aerozine-50 have not shown noticeable attack on alloys in static tests. Because of this, the static and dynamic testing is being conducted with N_2O_4 containing a maximum of 1 percent water.

Static testing consists of immersion of test specimens in the propellant contained in sealed stainless steel chambers immersed in a constant temperature bath. In the dynamic laboratory tests, specimen disks are immersed and rotated in the propellant to provide tip speeds nominally equivalent to the propellant flow-rates in the system. The dynamic exposure tests in the component test facility consist of inserting specimens in the pump discharge lines.

Materials under test include alloys of aluminum, stainless steels, copper, nickel, magnesium and titanium, weldments of these materials, brazed joints, wear resistant coatings, galvanic couples, and stressed specimens.

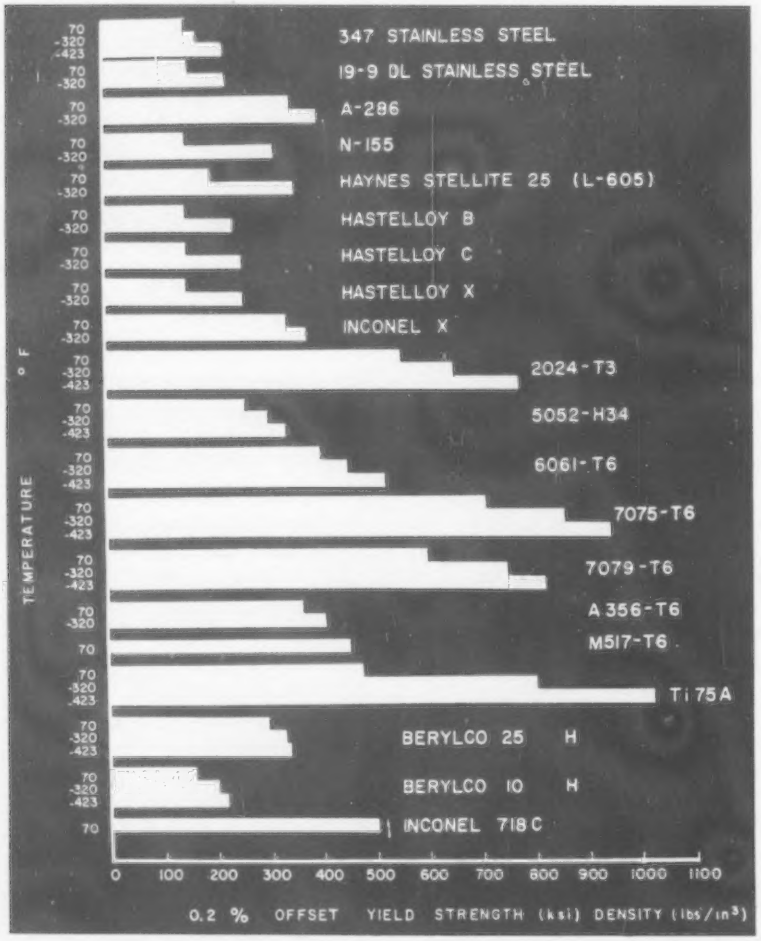

Fig. 3. Yield Strength-Density Ratios for Metals at Room and Cryogenic Temperatures.

Nonmetallics For N_2O_4—Initial screening tests of over 400 materials have yielded candidates for evaluation. In many categories no material has shown adequate resistance and basic material development action have been initiated.

(1) Elastomers: No available elastomer has yet been found suitable for extended service with N_2O_4. Upgrading compounds based on commercially available polymers has not been successful. Further development and the exploring of new fluorinated polymers is in progress. For short term (approximately one week) service the compound XB-1235-10 (a phenolic cured butyl by Parker Seal Co.) is satisfactory for static O-ring seals. This compound exhibits 65 percent swell, which though excessive, can be used in design. The LS-53 (fluorosilicones by Dow-Corning Corp.) based elastomers have shown better property retention then the butyl elastomers, but exhibit 185 to 400 percent swell.

(2) Thermoplastics: Dynamic and static seals and gaskets of unfilled or reinforced Teflon and Kel-F plastics (except Kel F-800) are recommended for extended service. Static seals and gaskets of filled Teflon and Kel-F plastics (except Kel-F-800) are also suitable for extended service. For short term service polyethylene (Marlex 50), Phillips Chemical Co., and polypropylene (Pro Fax), Hercules Powder Co., are suitable for dynamic and static seals and gaskets. Slow oxidation of polyethylene and polypropylene will limit their use.

Coatings and semirigid insulation of all the above polymers are feasible. However, the lack of chemical resistance, absorption of N_2O_4, and fabrication difficulties limit their application. The absorption of N_2O_4 by Teflon makes its use as an insulation for wire questionable.

(3) Lubricants: No entirely satisfactory lubricant is presently available for N_2O_4 service. Graphite and molybdenum disulfide pow-

der show good resistance. Three silicone greases are usable: Valve Seal A, High Vacuum Grease, and XC-150, all Dow-Corning Corp. products, but are expected to wash out. Halogenated paraffin greases such as fluorolubes by Hooker Chemicals, Halocarbon by Halocarbon Products, Kel F by Minnesota Mining and Mfg., and Arochlors by Monsanto are miscible with N_2O_4. This miscibility is inversely proportional to their viscosity.

(4) Miscellaneous — An antiseize thread sealant, "N_2O_4 Sealant" by Redel Inc., has been found suitable for use at low pressure.

Certain metallic and Teflon-backed pressure - sensitive tapes show suitable splash resistance. Minnesota Mining and Mfg.'s Y-9040 (aluminum foil backed) and X-1111 (Teflon backed) tapes are the best of those tested thus far. Sauereisen inorganic cements, specific phenolics, and phenolic-modified epoxy systems appear to be suitable as rigid insulations for both electrical and thermal applications.

Nonmetallics for Aerozine-50—(1) Elastomers: Certain butyl compounds show excellent resistance; however, their poor compression set property may reduce overall utility. Certain neoprene and GR-S compounds exhibit good resistance and may be usable. Testing of these materials is still in progress.

(2) Thermoplastics: Nylon per MIL-P-17091-B (Zytel 31 and Zytel 101: E. I. du Pont products, are examples) and Teflon can be recommended for use as dynamic and static seals, gaskets, coatings, and semirigid insulations. Kel F-300 and polyethylene exhibit "stress cracking" and are not recommended. Polypropylene absorbs Aerozine-50, but otherwise shows no degradation. Further testing is being conducted.

(3) Lubricants: Of the silicone oils and greases tested, Dow-Corning F-60, 500, 550 oils, and Valve Seal A, High Vacuum, DC-11, and XC-150 greases display adequate resistance, but have marginal lubricating properties.

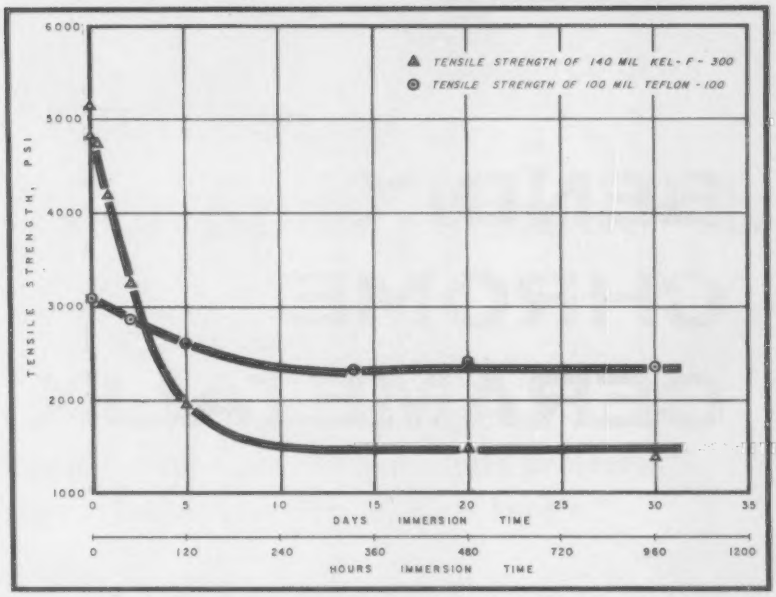

Fig. 4. Effect of N_2O_4 on Tensile Strength of Teflon 100 and Kel-F 300.

Similarly, some of the polyglycols produced by Dow Chemical Co. are resistant, but are poor lubricants. Neither the hologenated paraffin lubricants nor the molybdenum disulfide based lubricants should be used in contact with Aerozine-50, as these materials react very rapidly.

Graphite and Teflon powders do not appear to be chemically attacked or dissolved by Aerozine-50; however, they would tend to wash out. Redel Inc. has a "UDMH Sealant" that, based on screening tests, appears suitable for sealing threaded connections.

(4) Miscellaneous: From the data available the best adhesives for service in Aerozine-50 are inorganic, butyl, and chloroprene systems. They may be used as coatings, but their service life has not been determined. Some of the silicone electrical varnishes and PT-201G (a phenolic, epoxy, silicone tripolymer by Products Techniques Inc.) also have shown resistance to Aerozine-50.

Exhaust Gas System—The following metals offer promise for service in the hot exhaust gas system:

(1) Static Application: The iron based alloys type HK and Multimet N-155, and the cobalt based alloys Refractalloy 80 and Haynes Stellite Alloy No. 31 have the best thermal shock properties. They are suitable for high temperature static service. Their corrosion resistance to the hot exhaust gas and the propellants is being evaluated.

(2) Dynamic Application: The nickel base alloys are age-hardenable with the addition of titanium and aluminum and possess high strength at 1500 to 1750°F in the heat treated condition. Waspoloy, Rene 41, Udimet 500, Astroly, 713-C, Nicrotung, Udimet 700, DCM, and GMC-235-D are nickel-based alloys which are being considered for dynamic service. The cobalt-base alloy, Haynes Stellite No. 151, is suitable for dynamic service in the 1500 to 1600°F temperature range. These materials are being evaluated for hot exhaust gas corrosion resistance.

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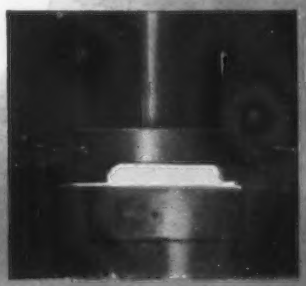
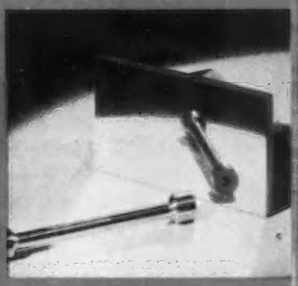


FORGEABLE, WORKABLE—Chrome Cerametalix can be forged and hot worked.

MACHINEABLE—This material can be precisely machined using conventional methods and equipment.



MICRO-SURFACE FINISH—Chrome Cerametalix can be polished to a micro-surface finish with standard machines.

Inflatable Structures For Space Research

Plastic film has proven good design material for balloons, satellites; Polyethylene and Mylar enjoy greatest use in immediate projects; Rigidizing structures after inflation next development hurdle

By Richard Braun,
Manager Viron Div., Geophysics Corp. of America

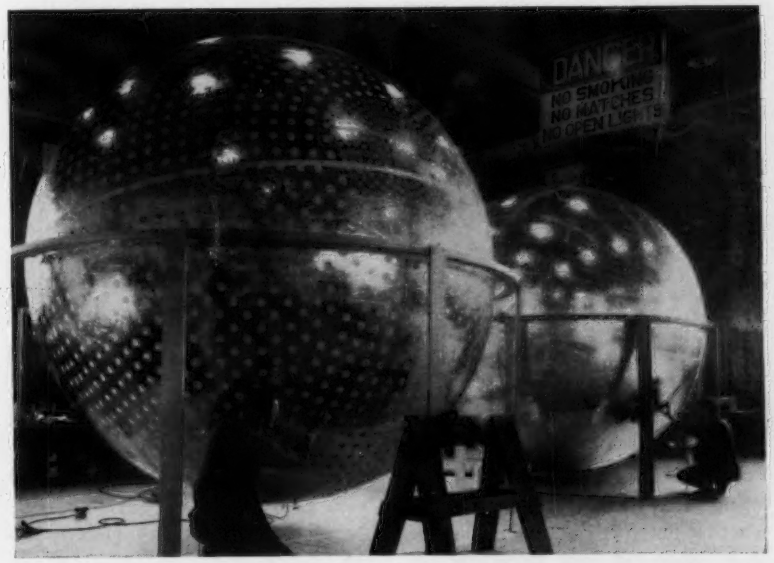
Plastic balloons have proven to be effective vehicles for investigating the atmosphere.

Extensive use of plastic for inflatable space structures is essential to scientific programs of the future.

Polyethylene—Most plastic balloons that have been flown to date are manufactured from polyethylene. Its properties are satisfactory for most balloon applications. Polyethylene used in balloons is usually from 0.0005 in. to 0.002 in. thick. This, of course, requires extremely good quality controls for both the extrusion of the film and the fabrication of the film into balloons.

At room temperature the yield point of polyethylene is approximately 1500 psi and the ultimate strength is about 3000 psi. At colder temperatures, which balloons reach in flight, the ultimate strength of the polyethylene increases substantially. However, the increase in material strength with the colder temperatures changes the stress-strain distribution and also the amount of energy required to being about fracture. At the colder temperatures, the energy required to cause plastic fracture is considerably less than what it is at room temperature.

Critical Temperature—Another consideration related to balloon design is the yield point of the plastic. In general, the yield point of polyethylene is compatible with balloon applications. However, one must pay particular attention to the differentials of loading and strains in the balloon when the film is within

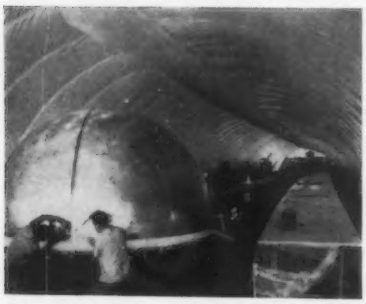


LAMINATED BALLOON shown is intended for air-density studies by NASA. Polka-dot pattern is for heat control. Four alternate layers of aluminum foil and Mylar give total thickness of 2 mils. Echo balloon used vacuum deposited aluminum; laminations give this 12-ft structure more rigidity. Attempted launch failed when Scout malfunctioned, Dec. 4.

Planners foresee balloons with 6000 lb load capability; Superpressure design would give flight duration of months

the temperature range of —30 to —45°C. In this temperature range the polyethylene goes through a phase transition which results in localized yielding. Unless the balloon is properly designed, for the —30 to —45°C. temperature range, balloon ascent could end catastrophically at 40,000 to 60,000 ft. Polyethylene film has a cold brittleness temperature characteristic in the —68 to —70°C. range and at the other end of the thermal range is sealable through the application of heat.

Mylar Promising—Another balloon film that is used less frequently, but which has an extremely good potential, is Mylar. An outstanding characteristic of this polyester film is the retention of high mechanical strength over a wide temperature range. At room temperature the yield point of Mylar is approximately 14,000 psi and the ultimate strength is about 23,000 psi. This compares very favorably to hard aluminum. The strength characteristics of Mylar increase with colder temperatures. No embrittlement occurs until —70°C. The combination of high tensile-strengths, low cold-brittleness, high transmission factors to solar energy and satisfactory sealing methods for Mylar identify a material useful for balloons and inflatable space structures. The physical properties of polyethylene and Mylar are compared in Fig. 1.



POLYETHYLENE ENCLOSURE inside main hangar at Langley Research Center is about 75 ft long. It is supported only by inside air pressure. This "clean room" is used to assemble inflatable space structures that will be launched into orbit by NASA's Scout.

Balloon Missions—Plastic balloons have probed the atmosphere vertically in the ascent and descent portions of the flight pattern and horizontally at altitudes up to 135,000 ft. This has provided data on electrical field and conductivity distributions, on atmosphere gases, particulate matter, geomagnetic fields, cosmic rays, radiation quantities, ozone distributions, and on atmosphere density. Plastic balloons have also been utilized to provide wind information at altitudes where only sparse radiosonde data is available. This information is, in turn, directly applicable to general circulation studies of the stratosphere.

Measurements have also been made of the earth's albedo, the vertical distribution of the atmosphere's composition, and related radioactive transfer problems.

The plastic balloon has been an effective platform for: carrying telescopes above the scintillation layers, solar constant measurements, measuring sky brightness above atmospheric scattering, spectral measurment of the aurora borealis, aeromedical experiments, and carrying multi-staged rockets to the edge of space that in turn are used to obtain data in space.

Balloons can be manufactured with radar reflective surfaces and, therefore, are useful as targets and in the support of various missile range projects. Since they are also capable of being launched from aircraft, they can be placed into the atmosphere within a given set of coordinates of time and location. Air launched balloons have been utilized to place a beacon in the eye of a hurricane at a level of minimum divergence so as to provide a means of tracking and studying the storms.

Superpressure Design—A promising design area in plastic balloons is that of superpressure balloons to provide continuous atmospheric information at various density levels in the atmosphere. This type of a balloon is essentially a closed, non-extensible, plastic envelope which maintains its lifting gas at a pressure greater than that of the immediate surrounding atmosphere. When such a balloon is flown at a predetermined density altitude and is subjected to diurnal variations of radiant energy, the internal balloon pressure fluctuates accordingly. The balloon volume, however, is essentially unchanged. The initial superpressure is programmed to exceed the internal pressure drop occasioned by the sunset effects and changes in terrestrial radiation and thus keep volume constant. This obviates the ballast requirements which hence maximizes the useful payload and will provide flight durations for extremely long periods of time. The superpressure balloon has the flight characteristics of flying at constant density altitudes and will provide wind information and circulation patterns through the media of tracking ground stations. In addition, other information can be telemetered from sensing elements carried by the balloon. At present, Mylar is the most satisfactory plastic for the fabrication of superpressure balloons.

Balloon Capabilities—The current capabilities of plastic balloons are generalized as follows:

(1). Size: About five balloons have been flown that are 10 to 15 million feet in volume. Thirty to

forty balloons, each with a volume of about six million ft have been flown. This particular balloon which is fabricated of 1.0 mil polyethylene has a length of about 350 ft, a diam of 250 ft and is capable of carrying a load of 1500 lb to 115,000 ft. Over one hundred balloons of three million cubic feet in volume have been flown and have established a reliability factor in excess of 90 per cent. Balloons of this size will carry 1500 lb to approximately 100,000 ft. Several thousand plastic balloons of smaller sizes have been flown on a very successful and reliable basis.

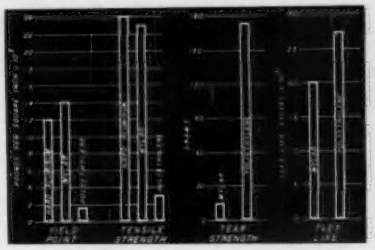
(2). Load Carrying Ability: The size and weight of the balloon, the weight of the load carried by the balloon and the desired balloon floating altitude are interrelated factors. Fig. 2 relates gross load (balloon weight plus load carried beneath the balloon) to balloon volume and floating altitude. The balloon weight for 1.0 mil and 1.5 mil polyethylene and 0.5 mil Mylar balloons can be determined from Fig. 3. To determine the load that may be carried from a balloon, one would subtract the balloon weight of Fig. 3 from the gross load of Fig. 2. The following description of loads is, therefore, related to a specific balloon volume and floating altitude. To date, loads of 3000 to 4000 lb have been successfully carried to 80,000 ft. Several hundred plastic balloon flights have been made with loads in the range of 1200 to 2000 lb to altitudes in excess of 100,000 ft.

(3). Altitudes: Several large, thin-gauge plastic balloons carrying very light loads have been flown to altitudes in excess of 130,000 ft.

(4). Durations: The duration of plastic balloon flights is related to proper balloon design and utilization of balloon control instrumentation that is compatible with the predicted thermodynamic behavior of the balloon. With intelligent design, it is possible to fly plastic balloons for durations that will be measured in weeks.

Projected plastic balloon capabilities include sizes in excess of 15 million ft, 3 loads in excess of 6000 lb, altitudes to approximately 150,000 ft and flight durations, with super-pressured balloons, measured in months.

FIG. 1. MATERIAL PROPERTIES for inflatable space structures are compared above. Polyethylene and Mylar are enjoying greatest use among films in current projects. ▶



Material Selection—The selection of the plastic material and the design of the satellite structure must be considered in terms of the forces acting upon the satellite in space. Forces tending to deform the satellite include: direct solar radiation pressure, solar radiation reflected from the earth, radiation pressures from the earth and the satellite, aerodynamic pressure, cosmic dust and micrometeorite pressures, magnetic forces and forces arising from rotation of the satellite. A determination of the deforming forces and forces tending to prevent deformation will in turn determine the necessary skin strength required for the satellite.

Rigidizing Inflatables—Methods are currently under study for rigidizing inflatable plastic space structures. This will provide a net capability of utilizing the high tensile strength, light weight and desirable packing characteristics of plastics for delivering the unit into space and then stiffening it after it is ejected from its package. The rigidization of the plastic structure in space will provide a structure that is not dependent upon the internal pressure for shape maintenance.

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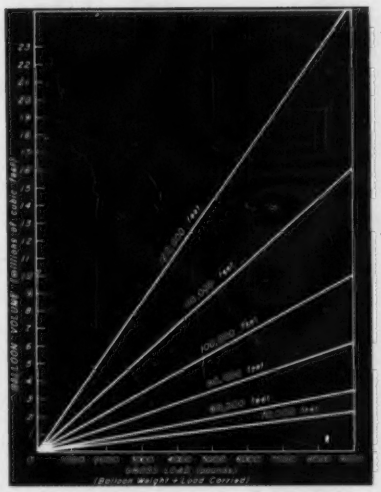


FIG. 2. LOAD CARRYING ABILITY of various size balloons is shown at different altitudes. Weight figures are gross, payload plus structure; to determine structure weight, see Fig. 3.

FIG. 3. STRUCTURAL WEIGHT of balloons can be held within the parameters of these curves with intelligent design. To determine payload carrying ability subtract balloon weight in this figure from gross weight in Fig. 2.

Chemicals— A Big Market In Aerospace

Propellants, structures, APU's offer chemical industry giant challenge; Non-chemical companies "diversifying" for chemical profits

By Paul M. Terlizzi, Asst. to V.P. for Research
Stauffer Chemical Co.

Missiles, satellites, and space probes in the period 1962-1972 will continue to use the "workhorse" propellant systems. Quantities used will be tremendous. For example, a single 1.5 million lb-thrust F-1 engine requires over 180 tons of chemicals for a one minute firing.

One use for this engine envisions it clustered as a Nova booster. Six engines would be used. This means a first stage Nova could burn 720 tons of liquid oxygen and nearly 360 tons of kerosene in one minute. Consider the number of tests, and flights programmed for our big boosters and the potential of the market is evident.

The Challenge Of Propellants— As thrust requirements for chemically fueled rockets increase to 10 or even 20 million lb thrust, permanent land bases for launching these "monsters" may be inadequate. Considerations are being given to sea launch sites. Propellant supply would be from tankers. Converted tankers are also considered as manufacturing sites for propellants. But, the feasibility of "piping" propellants "miles" out to sea launch sites will not be overlooked.

Isolated launch areas would prevent wide-spread contamination should nuclear radiation for upper stage propulsion result from launch accidents.

The chemical industry should consider this possibility. It should review chemical processes for new propellants to obtain an indication of the possibility of manufacture at sea, utilizing seawater, nuclear power, etc.

The future will see many new propellant systems. Higher density, higher energy systems will be needed to lift increased payloads. Hybrid systems will be explored to permit a "marriage" of advantages of both the liquid and solid systems. Ram jet systems will be used for intermediate stages.

As our penetration of space increases, new requirements will develop, and propulsion concepts may change to take advantage of latent energies existing in space. Chemical companies must keep abreast of these new objectives to maintain a competitive position in products which could be an outgrowth of their present or planned research, development and production capabilities.

Boron, fluorine, and lithium will play major roles in new propulsive systems. The proper combination of these high energy constituents suitable for selected applications will be the task cut out for the chemical industry.

Underwater Propulsion — The science of underwater propulsion is today in about the same state that aircraft propulsion was fifty years ago. Nuclear propulsion for submarines and surface vessels is with us now, and is performing satisfactorily. However, the propulsion of torpedos, small underwater craft, and special missiles will require new fuels and propulsion concepts. The field of water reactive chemicals employing the use of sodium boron and lithium based compounds will grow considerably.

Lithium and sodium as water reactive fuels have been suggested

by the U. S. Naval Ordnance Test Station, Pasadena, Calif. A specific fuel consumption of 1.5 lb per shaft hp was recently obtained by using lithium and sea water in a turbine system. But, half of the heat has to be converted to mechanical energy in expansion of the reaction products from 300 psia to atomspheric pressure. The NOTS underwater engine has been operated for 3 min at a 95 per cent combustion efficiency at 1000°F.

Avco-Everett Research Lab. has an underwater propulsion system built around a cavity reactor and magnetohydrodynamic generator that looks like it could produce enormous amounts of power per pound of propulsion equipment weight. A mix of uranium and some low atomic weight diluent are fed into a cavity and raised to a temperature of 10,000 K. Sea water could be used as a diluent. Some think an underwater system would be easier to engineer than a conventional rocket operating in the atmosphere or in a vacuum. Reason is that cooling would be much simpler since the vast amount of dense, cool sea water would be available for cooling purposes.

The Martin Co. is developing a system which produces electrical power from the heat liberated in the radioactive decay of Polonium 210 isotope. Conversion directly into electrical energy could lead to a truly silent, long-range undersea craft. If the Navy is thinking about an atomic armed torpedo, it could go all the way to a nuclear-propelled missile or torpedo. The chemical industry should watch this field closely. A lucrative market is in the offing.

Market Stability? — Now the most obvious question: What assurance does the chemical industry have that there will be a market for a better product? That a reasonable profit will be forthcoming? And, will a missile or space propulsion system stay put design-wise and budget-wise long enough to allow a chemical company to reap some benefit from its investment of funds, facilities and personnel?

CHEMICAL PROPELLANTS will do most "workhorse" tasks of space exploration in 1962-1972 period. Proposed vehicle would take 8 man crew in Mars orbit mission. Six or more chemical boosters would rendezvous in Earth orbit.

Congressional hearings have brought out that some missile and space programs are marginal from a strategic standpoint. Some should be cancelled to allow increased effort to be put into more promising systems.

These hearings and resultant recommendations have had one important effect. Missile and space propulsion systems in the future will be better oriented to long range requirements, thus assuring a steady market for selected propulsion chemicals for at least a five to ten year period. More funds will be directed toward providing reliability testing and standardization culminating in greater use of chemical propellants.

Exotic Propulsion—There is a misconception that new propulsive power techniques such as ion, solar, plasma, and nuclear, are substitute systems for lifting payloads from ground zero. This is not the case. For most efficient launchings from earth and planets chemical propulsion for booster and subsequent stages will continue to be used. Once the payload is outside gravitational influences, the other forms of propulsion will take over because of their efficiencies in a vacuum.

In nuclear propulsion chemical working fluids such as liquid hydro-

Materials are base of aerospace problems; Chemical industry can capture new markets

gen, hydrazine, and others will be used. Newer and more efficient working fluids still are needed.

A fundamental problem in accomplishing orbital transfers with large payloads is the limitation of chemical propulsion systems in deep space. Of necessity deep probes to our neighboring planets require more propellants, additional structures, and bigger initial stages to reach orbital speeds.

A step in accomplishing such missions is the use of electrical propulsion. This rather sophisticated system, in contrast to the chemical engine, requires a separate source of energy solar collectors or nuclear power plants could be used. A propellant such as cesium is vaporized on a tungsten surface and the ensuing ions and electrons are then subjected to electric fields which accelerate them to high velocities. Some of these units are now in the laboratory stage and small thrust engines of one to two pounds have been run. Calculations indicate that specific impulse values from ten to fifty times those for chemical systems may be obtainable. Chemical industry should not overlook the future market possibilities in electric propulsion techniques.

Auxiliary Power Systems—Advanced power generation techniques to meet future requirements for electric power in space vehicles present another market. Electric power can be generated in space from three basic energy sources, namely, chemical, nuclear, and solar.

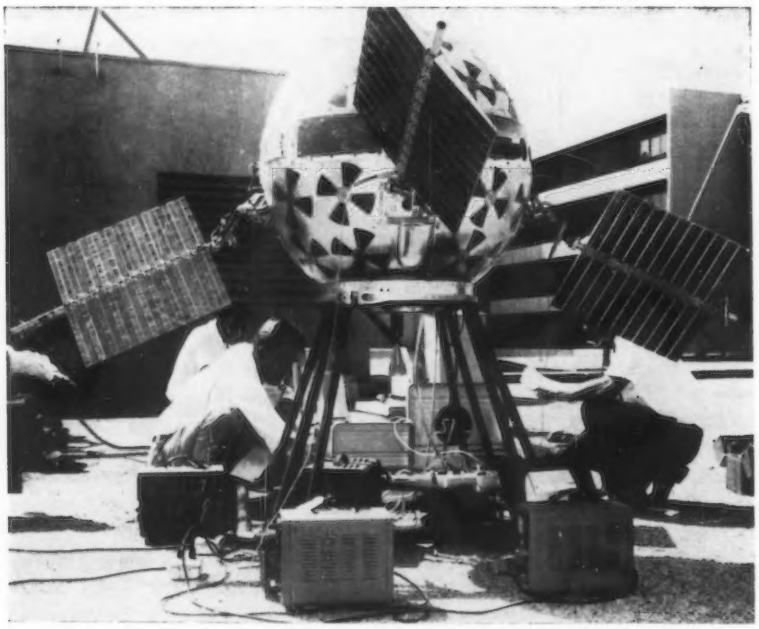
Solar cells are doing a good job at present. However, a severe disadvantage taking into consideration the requirement to maintain sun orientation of the solar collectors is the presence of perturbing torques such as could be caused by men moving around a space vehicle.

In unmanned craft more efficient solar cell material will be needed to operate in "shadows" or darker sides of planets. In addition, chemical industry can look to increased market opportunities in such solar cell materials as gallium arsenide and cadmium sulfate. Development of reflecting surface coatings which when applied will reflect only that portion of the spectrum to which the solar cell is sensitive and not the infrared portion which serves only to heat the cell without significant output are a possibility. Another technique requiring solution is a means whereby infrared radiation can be converted to visible light to produce electrical output.

Nuclear power generation systems are plagued with radiation hazards and shielding provisions for combating them. This often turns nuclear power to a disadvantage when comparing systems in terms of space application. The SNAP program (Systems for Nuclear Auxiliary Power) will lead to better efficiencies.

One of the key problems in the performance of fuel cells as a power generating source, is that control of phase separation between liquid and gaseous fuels may be troublesome in zero-gravity conditions.

Batteries Have Advantages—A chemical stored-energy system or secondary battery has considerable advantage. Nickel - cadmium and silver-zinc batteries will be utilized in increasing numbers in space probes and space vehicles. However, weight is a factor, therefore, some compromise must be made. Nickel-cadmium batteries hermetically sealed are the most suitable stored energy devices at this time. Chemical industry has much to contribute to the future use of batteries as a principal auxiliary power source, the development of more ef-



SOLAR CELLS find extensive use in most satellites. Explorer vehicle shown uses 2200 cells on paddles. Increased market opportunities in store for gallium arsenide and cadmium sulfate collectors.

ficient solar cell materials, and new fuel cell concepts. Quantity requirements although small at present, will increase as these systems begin to show promise as commercial power packs.

Fuel Cell Market—Fuel cells using hydrogen and oxygen as fuels have exhibited conversion efficiencies of more than 60 per cent. Steam turbines, which generate most of the electricity produced in the world today, have only a 40 per cent efficiency. Maximum theoretical efficiency for fuel cells is about 80 per cent. Fuel cells under development for space use include systems using nitrous oxide and chlorine, lithium and hydrogen, and photosensitive catalysts to decompose water to hydrogen and oxygen. Recently, General Electric released information on a 30 lb portable unit powered by ion-exchange cells that was equivalent on a weight-pound basis to 80 lb of batteries. Lithium hydride provided the hydrogen and air the oxygen. A breakthrough in any of these systems during the next few years will have a considerable effect on the supply of chemicals for energy conversion applications on a commercial scale.

Life Support Systems—For the astronaut, new problems await in space. He must take all his food and air with him. He must be able to live for days, weeks, and possibly months between takeoff and landing in a capsule.

Life support systems are still crude and more efficient methods and techniques are needed: to recover usable water from body wastes, to treat CO_2 and obtain life sustaining oxygen, to improve food concentration, and to develop new chemical survival techniques. The "larder" of our space ship will be stocked with high energy food prepared on earth. Packages will be organic materials that can either be eaten or ground with other waste and introduced into a waste conversion system. The more efficient these techniques, the longer the space flight or the greater the payload that can be put into orbit.

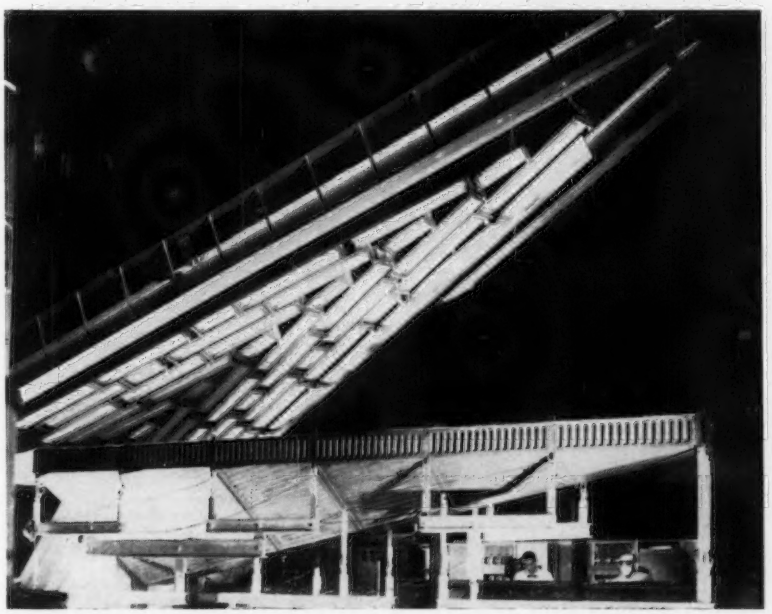
Materials—Space vehicles travelling within our solar system will be exposed to hazards detrimental to materials of construction. These environmental hazards include temperature, high vacuum, radiation, and meteorites. The availability of materials to withstand these hazards constitutes a phase of space effort upon which success or failure of a project often depends.

Requirements are varied for applications, however, a few generalizations can be made. Today's high-usage plastics will find little application as external coatings or external components. In a high vacuum 10^{-4} to 10^{-6} such as exists in space, plastics or polymers subjected to heat would form gases and volatilize. When portions of a polymer or plastic can be volatilized at fairly low temperatures, it can be anticipated that additional driving forces created by extreme low pressure will cause degradation of the material. New, highly cross-linked composite materials, however, offer a good market potential.

Next to human beings, semiconductor materials used in transistors and crystal diodes are most susceptible to damage from protons, electrons, and secondary radiation. Gamma rays and fast neutrons cause atomic displacements in metals with loss of ductibility. New semiconductor materials are needed.

Space vehicles re-entering earth's atmosphere after planetary explorations will execute "gliding" maneuvers and approach earth without decrease of speed. The vehicles will be so designed as to expose a minimum of leading edge surface. Materials, not yet developed, are needed which will expand and contract within selected ranges of thermal loading to assure airframe rigidity. In addition, more efficient chemical cooling techniques, also yet to be developed, will play important roles in this area.

To give an idea of what materials are expected to withstand, special high temperature tunnels are now being used capable of producing air speeds in excess of 20,000 ft/sec., Mach numbers in excess of 20, and temperatures up to 17,000°F. In addition, special facilities have been developed to study meteroid impact.

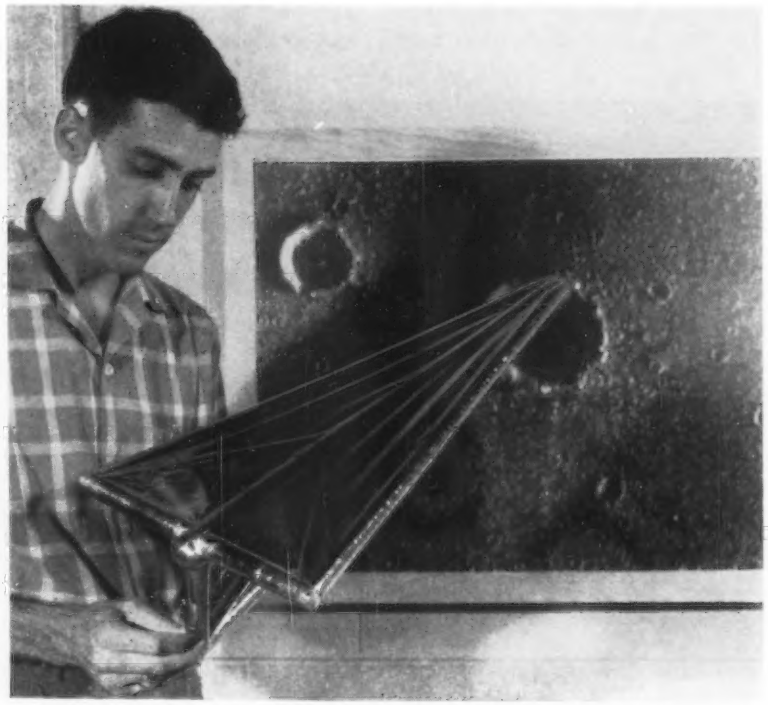


REENTRY MATERIALS and structures are being researched at NASA. Large market exists for substances which will expand and contract within selected ranges of thermal loading to assure airframe rigidity. Model under quartz-lamp heat is made of Inconel X.

Chemical industry could improve this aerospace hardware: Solar cells, batteries, life support systems, propellants

Project Pontus—In order to expand the boundaries of heat, several very sophisticated programs of basic research are underway under the support of the Department of Defense. Project "Pontus," covering basic research in the field of solid state physics, inorganic chemistry, and mechanics is oriented towards increasing basic knowledge in these areas as an assist to the development of new concepts which will increase our projection into space. These new concepts may be a combination of many principles new and old and may very well open up new markets for the chemical industry.

A multi-million dollar contract was recently awarded to a chemical company to develop a new type of graphite for missile and space components. There are many such programs underway, however, no one material has universal application. Because of this, continuous R & D is necessary to keep up with changing requirements. In addition, management must keep abreast of developments in order to gauge possible effect on commercial markets. The successful development of a new material of construction as a space vehicle skin may trigger off a huge requirement for a chemical intermediate.



FOLDABLE SPACE VEHICLES are being studied by NASA. Plastic films and special fabrics offer chemical companies many research and market opportunities. Model shown is used to test micro-meteorite impact, materials of construction are aluminum foil and polyethylene.

Non - Chemical Competition—Who is the competition to the chemical industry in space. Fifteen years ago practically all chemical propellant and material development work was done by the chemical companies and by "in house" Government activities. Since that time, aircraft companies seeing the decline of manned aircraft utilization "infiltrated" the rocket engine area and as a necessary adjunct also worked on propellants in order to develop complete systems. From propulsion techniques they entered material development, missile structures, ground support equipment, space environment, electronics, etc. Chemical companies soon noticed this activity and the market potential.

In 1957, the Department of Defense and its agencies initiated a concentrated effort to bring chemical companies into the space and missile program.

Large research and development programs were offered with complete responsibility for pursuit of goals left entirely to the company's research staff. As a result, chemical companies such as 3M's, Dow, Monsanto, American Cyanamid, Allied Chemical, Union Carbide, Stauffer, Esso, Olin Mathieson, Food Machinery, Hercules, Thiokol, etc., were given opportunities to lead the way to more efficient propellants and materials and to more efficient preparative methods.

The future will see more and more projects directed to chemical companies who are willing and able to assign personnel and facilities to such programs.

◆

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Filtering H_2O_2 In X-15

Wound-wire filter element made of 304 stainless, Removes 98 percent of particles over 10 microns

X-15 has two auxiliary power units. They supply hydraulic, and electrical power during flight. Each auxiliary power unit is rated at 40 hp. The units operate in parallel but independently of each other. Bringing hydrogen peroxide into contact with a catalyst bed of silver screens decomposes the liquid into steam and oxygen. These hot gases impinge on and drive a single-stage, axial-flow turbine at high velocity.

An electrical generator connected to the turbine produces electrical power to energize 1300 lb of instrumentation, the heating elements throughout the aircraft, the inertial guidance system and its computers, and communication, telemetering, and recording equipment. Hydraulic pumps, also driven by the turbine, operate speed brakes, landing flaps and control surfaces.

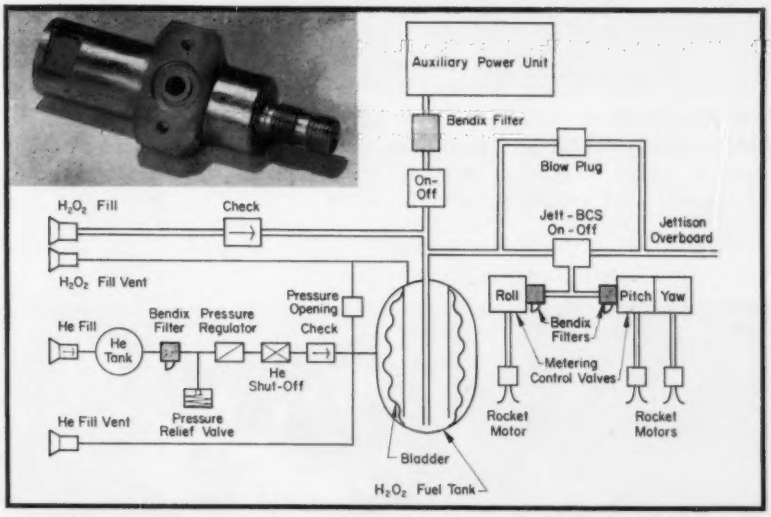
Keeping H_2O_2 Clean—To prevent the hydrogen peroxide metering valve from binding or eroding due to foreign particles, the hydrogen peroxide is cleaned to a level of 10-microns. A specially designed filter assembly (Bendix Filter Div.) containing an 18-8 type 304 stainless steel wound-wire filter element does the job. Stainless steel was selected because of its corrosion resistant properties and its wide operating temperature range, from 100 to 300°F. The filter assembly is rated to flow one gpm of hydrogen peroxide at 70°F and 700 psig. At rated flow, pressure drop is less than 10 psi. The filter assembly contains a safety by-pass valve with a differential cracking pressure of 40 psi. A similar filter cleans helium gas used in fuel tank purging and pressurization operations.

Filter material is called Poroloy, and is made by winding fine flattened wire in to a tublar shape with a special machine. This machine will handle wires with diameters as small as 0.001-in. It winds the wire at speeds up to 1000 ft. per min. The wire is wound with a rotational accuracy of one part in ten million for extremely accurate pore size control.

Different winding patterns determine the shape and size of pores. The number of layers of wire, which can be varied from 4 to 30, controls the permeability. This wire winding process had been used to produce porous metal tubes with diameters up to 12 in.

The X-15 stainless steel wound-wire Poroloy filter is sintered in special furnaces in an atmosphere of pure dry hydrogen. This bonds all crossing wires at each contact point. Sintering maintains rated pore sizes, adds high strength to the wire structure, and also prevents any possibility of media slough-off or migration, into the flow stream of hydrogen peroxide or helium.

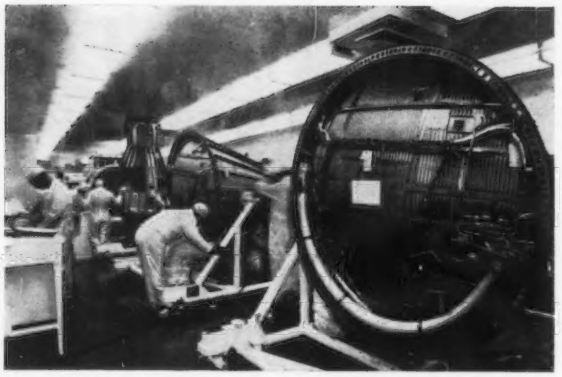
Combination Filter — The wound-wire Poroloy filters for the X-15 auxiliary power units act as combination depth and surface type filters. As a surface type, these filters have a characteristic sharp cut-off, so that they remove 98 percent of all particles whose two smallest dimensions exceed 10 microns, and 100 percent of all particles whose two smallest dimensions exceed 25 microns. The depth filtration characteristics tend to remove a great degree of sub-nominal sized particles and fiber contaminates. ◆



FEED SYSTEM for auxiliary power unit and ballistic control system in X-15 shows location of special wound-wire filter for hydrogen peroxide. Eight nozzles in X-15's nose, and four in wing produce 40 to 100 lb thrust for control beyond Earth's atmosphere. Stainless steel, 10 micron filter is shown in inset; has combination surface and depth action.

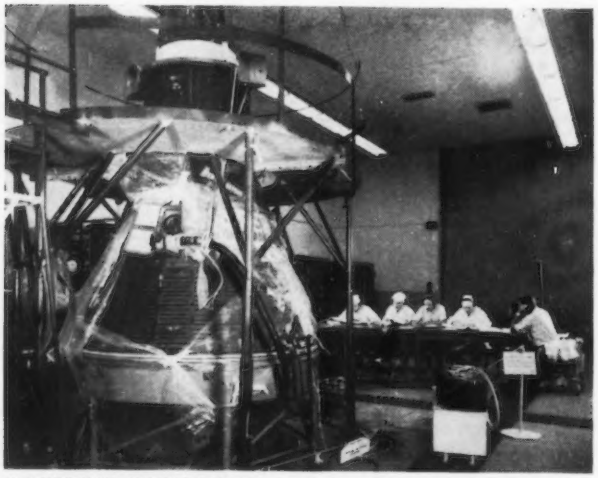
Monitoring Mercury Progress

An A&M Pictorial



CAPSULE ASSEMBLY is done in "white rooms" at McDonnell. Nine of twenty capsules ordered have been delivered. Three shifts are working seven days a week to speed availability of Mercury capsules. NASA still expects manned orbital flight in 1961.

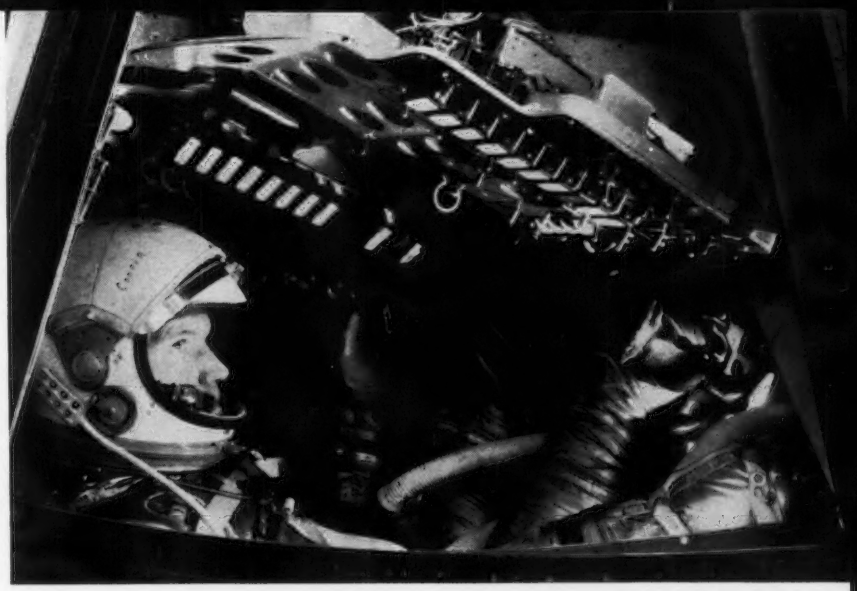
DESIGN CHANGES are not being retrofit in Mercury capsules; but, over 30 changes have been made during production. These include: window, now large rectangle of polaroid glass that cuts down on reflections from inside capsule; new escape hatch, there are now three means of egress; structures, beryllium sheet replaces nickel-cobalt alloy around parachute canister.



CAPSULE CHECKOUT includes hundreds of hours of systems tests before capsule is delivered to NASA. Each Mercury capsule contains more than seven miles of wiring. Environmental control system is checked out with capsule in pressure chamber.

◀ **ASTRONAUTS WATCH** demonstration of equipment in Mercury Control Central. This facility at Cape Canaveral will monitor capsule location and attitude, functioning of systems, and condition of astronaut. Data from each tracking station will be transmitted to central computing at Greenbelt, Md. L to R are astronauts-in-waiting Slayton, Schirra, Grissom, Shepard, Glenn, Carpenter, and Cooper.

MAN IN MERCURY will control the capsule and its systems with 122 controls: 57 electrical switches, 31 fuses, 34 mechanical levers. "Man-in-can" impression has been dispelled. Astronaut will monitor, backup, control most systems.



ABORT BUTTON enjoys prominent position at top left of pilots panel. Rectangular lights below button are used by pilot to monitor automatic flight sequence. Lights show green, top to bottom, as launch and reentry events proceed properly. If an event fails, the nameplate lights red and pilot resorts to manual override. Procedure gets a little more complicated at times.

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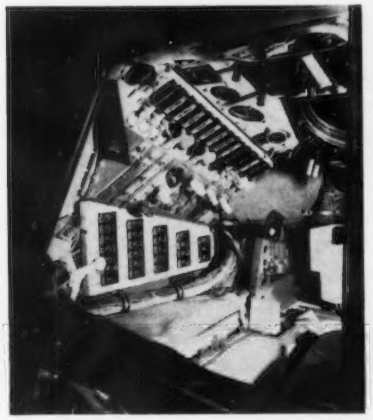

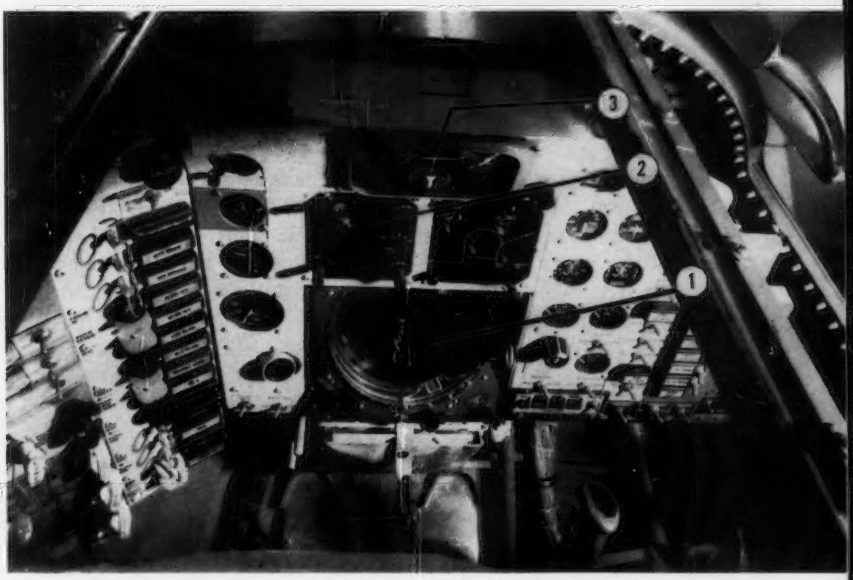

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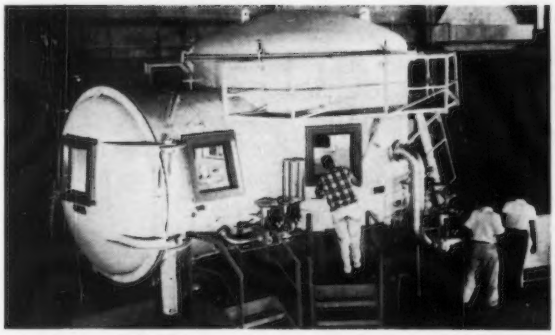
KEY FLIGHT INSTRUMENTS are at center of pilots panel: (1) Periscope for navigation, (2) Earth path-indicator, (3) Attitude rate indicator. Latter instrument is "cross-hair" type device to display rate of pitch, roll, yaw. Horizontal bar shows pitch, bottom half of vertical bar shows yaw; both these needles are calibrated for 12 deg/sec full scale. Top half of vertical bar shows roll rate and is calibrated for 4 deg/sec full scale. Scales are not numbered. Angles of pitch, roll, and yaw are shown on dials surrounding the rate indicator. Pilot will put capsule in critical retrograde attitude through rate indicator if automatic system is not functioning.



MERCURY POD installed recently at Canaveral by Tenney Engineering will be used to accustom astronauts to living in the vacuum environment of space. Doctors will monitor reactions. Detailed space environment studies are done at Philadelphia Navy Yard. Centrifuge capsule at Johnsville is used for G studies.

Glass Liners For Wind Tunnels

Britain develops small tunnel-nozzle of fused silica, Is unaffected by heat generated at Mach 5+

by Ronald A. Cole

Britain's Royal Aircraft Establishment has produced a hypersonic wind tunnel that uses a nozzle virtually unaffected by heat. Of the intermittent type, this tunnel has a 7 x 7 in. working section and can operate over the range from Mach 5 to Mach 9. The two dimensional nozzle and expansion chambers consist of liners which are particularly profiled for each speed and clamped together in a pressure tight box.

Hypersonic tunnel performance is critically dependent upon the height of the nozzle slot and the contour of the liners downstream from it. Inaccuracy in the slot height will give a different set of flow conditions than those for which the profile has been designed. Deviation from the ideal profile of the liners will also adversely affect performance.

For a speed of Mach 7 the slot height is no more than 0.067 in. and yet the temperature rise during a run can significantly change this dimension if steel liners are used. To make matters worse, the change will be progressive throughout the run and the degree of distortion will not be constant across the width of the slot. Upon cooling, some residual strain will be left in the steel, and as this is additive from one run to the next, such blocks unfortunately have a limited life cycle.

Uses Fused Silica—By employing fused silica, the advantages of low coefficients of thermal expansion and thermal conductivity are used. The short duration of tunnel runs allows the latter characteristic to be usefully employed in restricting dimensional changes. Other important features exhibited by the material include the fine finish that can be obtained by grinding, and the hard errosion resistant surface.

At the time the material was chosen, it was realized that it could be easily chipped and cracked and that carefully working and handling would be necessary. In addition, some means of assembling the nozzle and holding it in place, without putting high stresses in the silica, would have to be found.

This basic design problem was solved by using a clamping box constructed from thick plates of Invar. Variation of the nickel content in this nickel-iron alloy allows a material with almost any co-efficient of thermal expansion to be obtained. In this case the particular alloy chosen exhibits an expansion similar to that of glass.

Each face of the box dovetails into the other and then bolted. This action, gently but firmly, clamps the top and bottom liner blocks and their side plates into a pressure tight assembly. Sheets of Hallite jointing material between the silica and Invar plates seal any air that may leak past the mating surfaces of the blocks. The whole assembly bears on an end plate of Invar. This transmits loading into the box sides. At the front end the box is located by spherically ended pins.

Preparing The Silica—At first considerable difficulty was experienced in obtaining blocks of the raw material of sufficient size and quality. If the impurity content is too high numerous bubbles form in the casting and these give a poor surface finish. Eventually, The Thermal Syndicate undertook to supply the blocks which weigh up to 40 lb and are almost three feet long.

As received the silica blocks are rough and have no suitable flat or mutually perpendicular faces to use as a datum. The first face to be ground is the bottom or base surface and this is then used as a reference plane. Since the block is of a wedge shape it is necessary to support it with this face parallel to the table. This is done by casting two blocks of cold setting Araldite on the sloping face. A chalk filler is employed in the mix. It has been found advisable to remove the blocks as soon as possible, since continued shrinkage can damage the surface of the silica.

After grinding the reference face the blocks are turned on their side and clamped to angle plates while one of the sides is ground. For these operations the grinding head is disconnected from its template follower. Rabbets along the edges of the profiled blocks accommodate the thickness of the side plates in the final assembly and their formation requires the removal of a lot of material. For this operation, the blocks are placed on a Ballinger glass cutting machine and the rabbets are roughed out, using a diamond-impregnated slitting saw. A small allowance is left on for final grinding.

At this stage the overall shape of the block has been reproduced although the aerodynamic profile has yet to be formed. Again a lot of silica has to be removed from some portions of the face and the Ballinger machine is again used to speed up the operation. With the block placed across the machine a ¼-in. wide diamond-impregnated saw is used to produce a stepped pattern. This approximates to the final profile but leaves plus 0.05 in. at each point for final grinding.

With the block back on the profile grinder, roughing down of the stepped surface starts using a table speed of 6 ft/min and a depth of cut varying between 0.003-0.005 in. When the shape is to within 0.005 in. of the final profile the passes are made using the same speed but a depth of cut not exceeding 0.0003 in. At the end of each pass the table is fed across the wheel by about 0.02 in.

When the profiling is completed the rebated surfaces are finish ground to an equally exacting method. During this operation a very close check on the squareness of the planes to each other is made, for the ultimate pressure tightness of the nozzle depends on the close contact of these surfaces.

All the machining is done with diamond-impregnated wheels. The diamond plated type were chosen on account of their cooler and freer cutting compared with those where the diamond is set down in a metal matrix. Chucking and clamping is effected by using rubber blocks under clamps.

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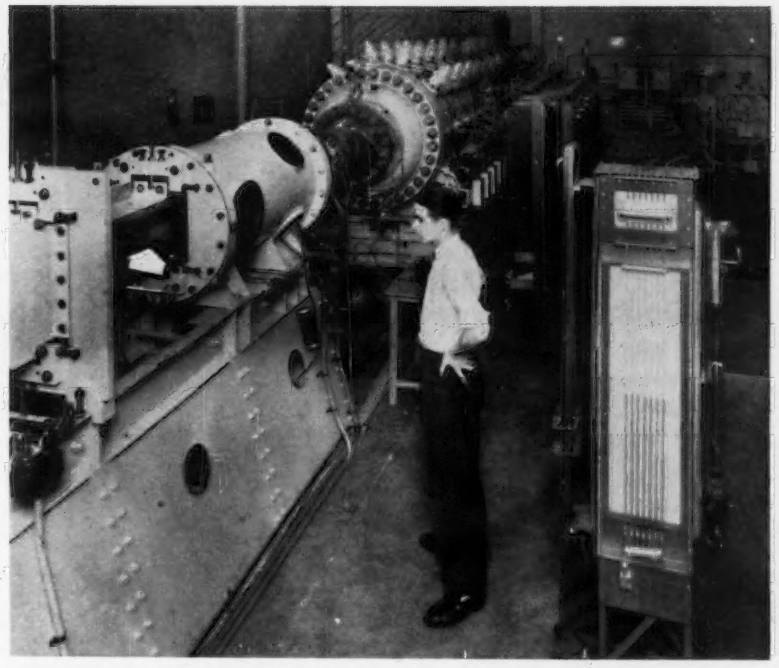
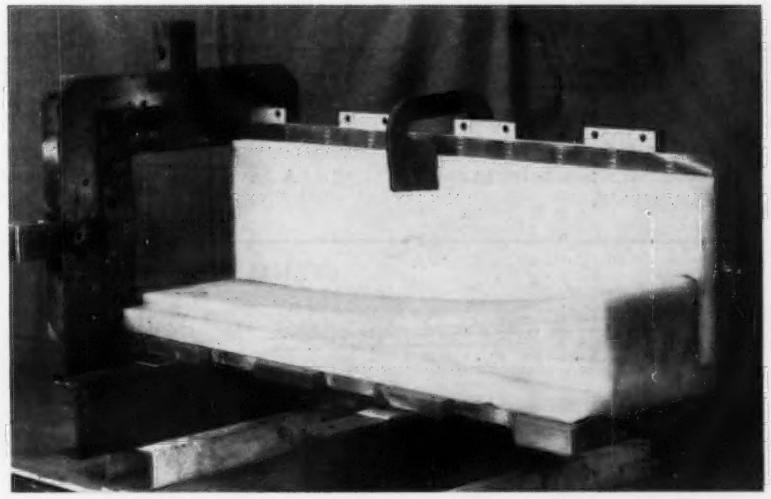


HYPERSONIC WIND TUNNEL at Farnborough incorporates fused silica nozzle area (arrow). Working section has a side plate removed. The nozzle box is housed in the cylinder shaped casting.



INVAR BOX is shown during assembly with two of the fused silica components, a profiled liner and a side plate, in position. The Hallite jointing sheet between the liners and the box walls make a pressure tight joint to seal any air that may leak past the close fitting rabbets in the liners.

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Seal Ups Fitting Reliability

Standard fittings obsolete for new fluid systems, Double seal types used for hi-temp, hi-pressure, and hi-reliability.

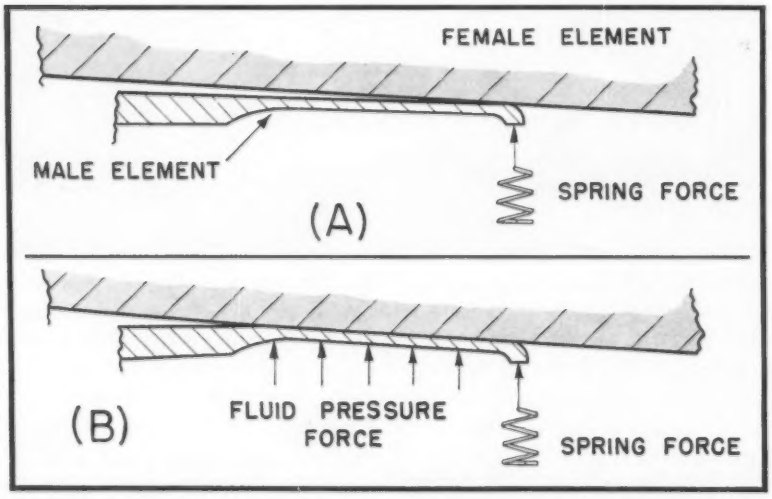
By W. A. Rademaekers, Manager
Mechanical Products Dept.
Titeflex, Inc.

Real hot temperatures and ultra-high pressures in fluid systems make standard AN and MS fittings for aircraft and missiles obsolete. Why obsolete? Note the following three points:

(1). High temperature characteristics—Performance of AN and MS fittings is largely dependent on keeping initial tightness of the threaded connection between mating halves. As temperatures exceed 500°F, these designs may leak due to relaxation of the threaded members.

(2). Adaptability to new materials—as temperatures and pressures of fluid systems rise, there is a corresponding increase in the need for new tube and fitting materials. Two alloys currently being evaluated for aircraft tubing are AM 350 and 17-7 ph stainless. Fittings for these tubes must not only meet higher performance specifications but also must be compatible from a manufacturing and assembly point of view.

(3). Need for fail-safe feature—System failures traced back to conventional types of tube fittings have led many designers to use special fail-safe devices in their plumbing



PRESSURE ASSIST SEAL principle. The interference fit makes an initial seal (A). Fluid force causes the male member to expand (B), giving a tight sealing action.

TABLE I

TEST PROCEDURE FOR DOUBLE-SEAL FITTINGS

PROOF PRESSURE TEST:

Proof pressure as listed below for different size tubing was maintained for a period of five minutes.

BURST PRESSURE TEST:

The "A" seal was damaged to all sealing to occur at the "B" seal. After a five minute proof pressure test, pressure was increased at a rate of 25,000 psi per minute until the tube or fitting failed.

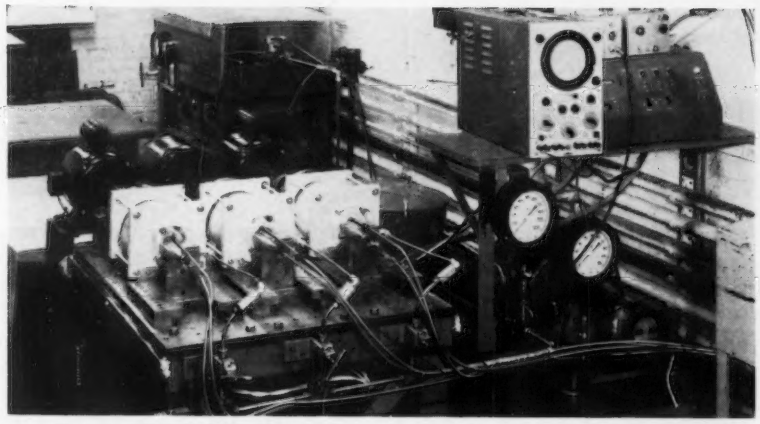
IMPULSE AND VIBRATION TEST:

After proof pressure test, samples were mounted on the vibration stand. This equipment was designed to allow simultaneous application of pressure, impulse, mechanica vibration, and elevated temperature. Values of each of these parameters for different size tubing are given below.

Tube Size OD x Wall	R T Burst psi-calc.	Operating psi at 600° F	Proof psi
0.25 x 0.010	14,800	3300	6600
0.50 x 0.015	11,000	2000	4000
1.00 x 0.015	5460	1200	2400

Impulse Peak psi	Amplitude to Produce Indicated Stress, in.		
	20M	30M	40M
5000	0.066	0.099	0.132
3000	0.033	0.050	0.066
1600	0.016	0.025	0.033

Results of some of the testing are given in Table II.



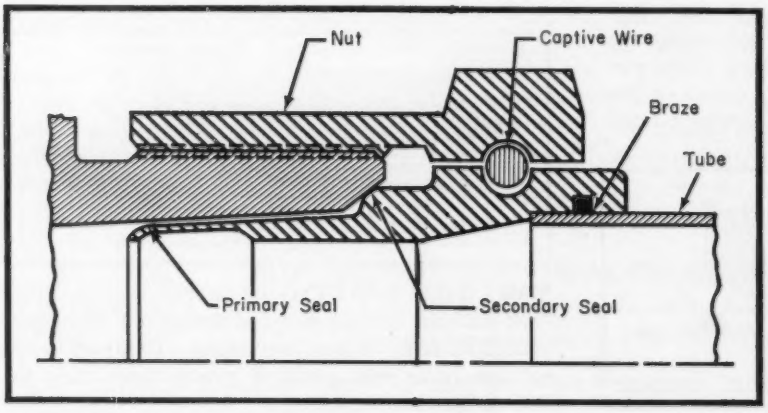
SPECIAL TEST EQUIPMENT is designed for evaluating tube and fittings at extreme operating conditions. Three fittings can be tested simultaneously under various combinations of temperature, pressure, vibration and hydraulic surge. Temperature is maintained by electric heating elements. Hydraulic equipment at right is for inducing hydraulic surge patterns which are measured with the oscilloscope on the shelf above this equipment.

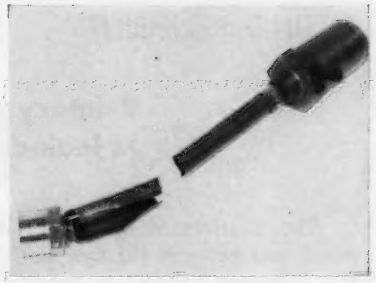
systems. In some instances, a complete duplicate piping system has been included.

To lick the problems, many fitting manufacturers have been carrying on research and development projects. One such program, started almost three years ago at Titeflex, Inc., has resulted in a family of new fittings.

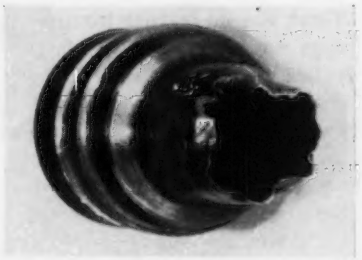
One feature common to the whole family of new units is a unique pressure assist seal. It consists of two elements. The male element has a thin-wall, slightly tapered end which engages the female part with a closely controlled interference fit. By undercutting and tapering the bore of the female, the result is a set of non-locking, tapered surfaces with a predetermined spring force.

DOUBLE SEAL FITTING has two sealing surfaces when fitting elements are assembled and held by coupling nut. Method of brazing tube to fitting is shown at right.

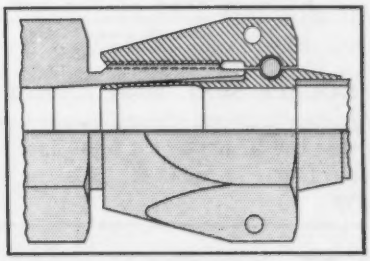




TYPICAL BURST TEST sample of double seal fitting brazed to 17-7 tubing. Fitting remained leakproof and performed satisfactorily up to rupture point of the tube. During early phases of this development program, one of the main problems was inconsistencies in performance and properties of tubing itself.



END VIEW of double seal fitting shows extent to which primary seal has to be purposely damaged before it would fail to function. This was necessary to evaluate secondary seal and is significant because it indicates that the fitting is not particularly sensitive to damage in routine handling.



PARTIAL CUTAWAY shows how pressure assist principle has been incorporated into a practical fitting for aircraft use. It can be used with new types of tubing such as AM 350 or 17-7 ph stainless as well as conventional types of stainless steel.

Primary seal failure activates remote alarm in leak-detecting variation of double seal fitting

The interference fit makes an initial seal between the two working members. Then, as internal pressure is applied, the fluid force causes the male member to expand elastically against the female, thereby reinforcing the sealing action. The higher the pressure, the tighter the seal.

To measure the effectiveness of the pressure assist feature, the threaded members of prototypes have been disconnected while full operating pressure was maintained. There was no leakage from the fittings nor could the two halves be pulled apart as long as pressure was applied. When pressure was released, the fittings could be disconnected with relative ease. The fitting can be reused many times without impairing the sealing action.

Double seal fittings are a refinement of the pressure assist type. This configuration was developed to provide greater reliability at elevated temperatures and pressures, and was designed to use 17-7ph tubing.

High reliability is obtained by a primary seal of the tapered spring, pressure assist type, backed-up by a "B" seal. The latter is a cone and spherical seat design which has a proved record of performance.

This design has been subjected to extensive testing for both engine and airframe applications. In some instances, testing was done in accordance with the requirements of a specific engine or aircraft. Table I summarizes a test program conducted in cooperation with a major engine manufacturer. It calls for tube and fittings assemblies that can operate at temperatures of 600°F and pressures from 1200 to over 3000 psi.

A leak-detecting fitting has been designed which is a minor variation of the double seal fitting. A bleed hole is added between the two seal surfaces and connected to a conventional detecting device. Failure of the primary seal actuates a remotely located signal light or similar alarm. The fitting will continue to function satisfactorily on the secondary seal. With further modification, this fitting can be used for coaxial fluid systems with either rigid or flexible tubing.

All of these fittings were designed for use with precipitation hardening grades of stainless steel as well as conventional grades of stainless such as Type 321. In using them with 17-7ph stainless or AM 350, the tube and fittings can be assembled by welding or brazing. However, brazing is generally preferred because it offers more flexibility in the use of dissimilar alloys, and makes it easier to combine the manufacturing operation with the heat treatment of the tube and fittings.

✦

TABLE II

TYPICAL TEST RESULTS—DOUBLE SEAL FITTING

Tube Size OD x Wall	Proof psi	Total Impulses	Impulse Time hrs	Vibr Amp in.	Total Vibr × 10^6	Burst psi
0.25 x 0.010	6600	14,000	6.66	0.062	2.12	12,050
0.50 x 0.015	4000	5834	2.67	0.083	0.32	14,300
1.00 x 0.015	2400	91,764	43.5	0.014	10.1	5050

FITTING TEST DATA

1. Burst Test
   #8 (½ in.) size—Pressure increased to 31,000
   #10 (⅝ in.) size psi, the limit of the test equipment. No leakage or other failure detected.
2. Vacuum Test ("B" seal eliminated)
   #8 (½ in.) size- No leakage detected after 72
   #10 (⅝ in.) size hr full vacuum (28 in. Hg)

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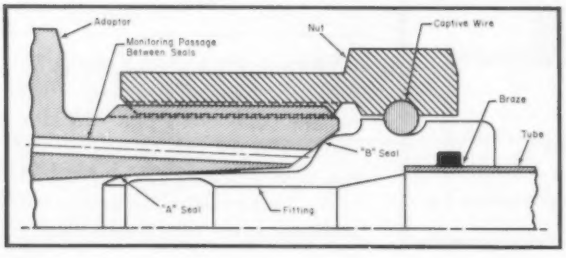
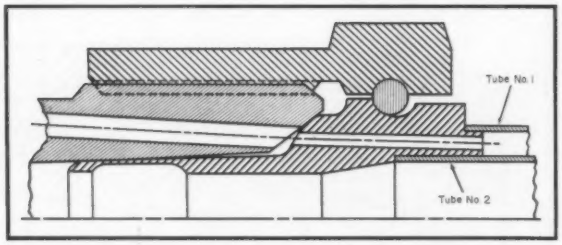
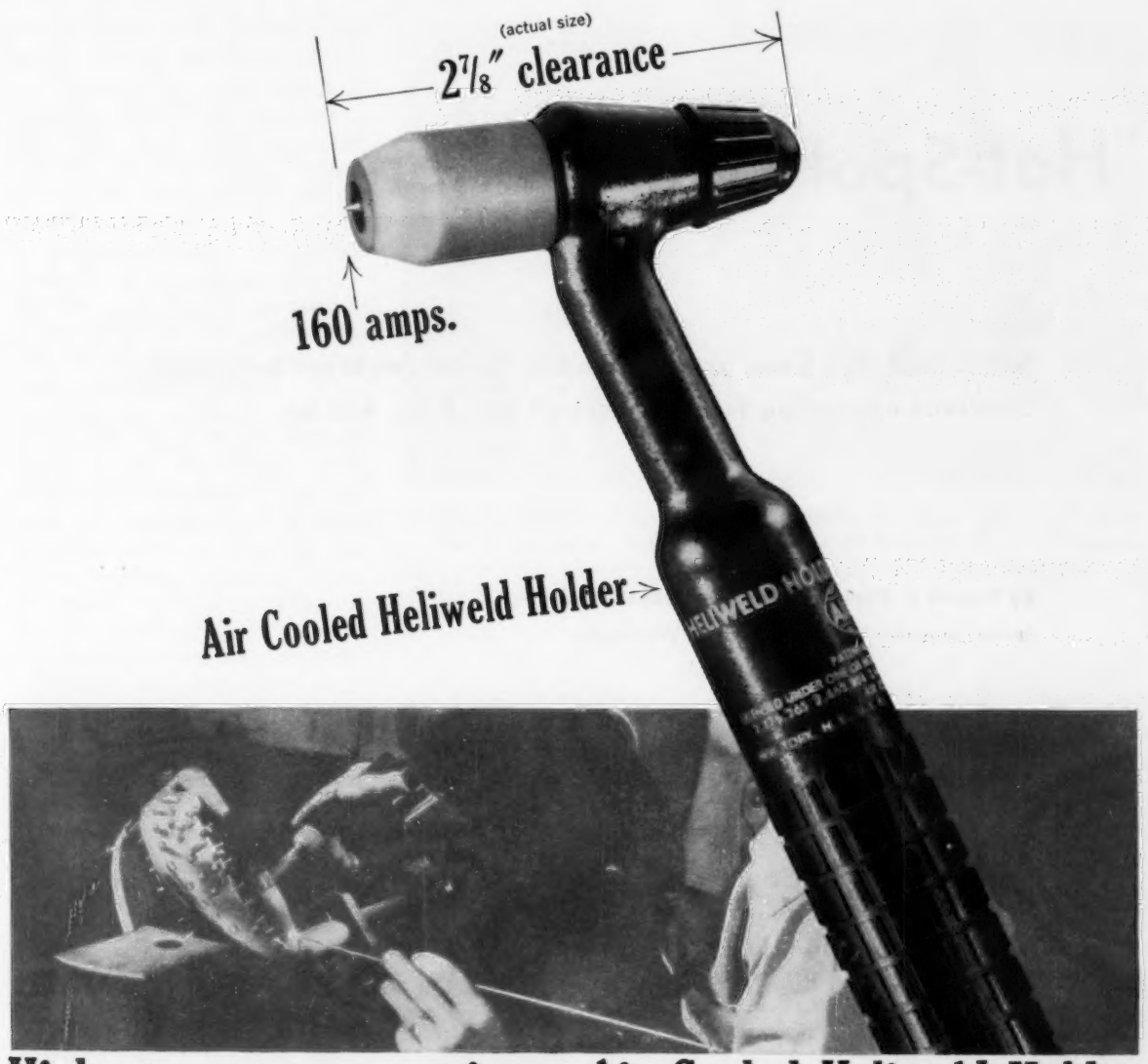
DOUBLE SEAL fitting modified to use monitoring passage between the two sealing surfaces. This passage can be connected to an indicating device so that any failure of one of the seals can be remotely detected.

▼





SIMPLIFIED DRAWING shows one of several possible methods of using modified double seal fitting with concentric tubes or hose assemblies. Proposed design has two tubes with a drilled passage connecting the volume between the tubings.



Highest amperage yet in an Air Cooled Heliweld Holder

New Airco H16-A. Only 2⅞" interference dimension and no water system! The new Airco H16-A Heliweld Holder, for tungsten-inert-gas welding, is the only air cooled holder available with 160 amps AC or DC – and it's the easiest to handle. Here's the holder for work in tight spots!

The Airco H16-A is a gem for jobs requiring rapid, clean, smooth welds on thinner gauge aluminum, alloy and stainless steels, brass, cast iron, copper, magnesium, molybdenum, nickel, silver, and many others.

Airco produces everything you require for manual and automatic Heliwelding. The line includes the H10 air cooled, H20 water cooled, H35 water cooled, and H50 water cooled Heliweld Holders, and automatic machine heads.

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"Hot-Spot" Lubrication

Silica/vat dye base grease used in thrust reverser bearings, Survives operating temperature of 450°F for 400 hr

By Donald J. Corley and **Ficklin Schenk,** Engineers
Boeing Airplane Company, Seattle, Washington

Operation of the Boeing 707 thrust reverser depends on free movement of 60 bearings in the control linkage. These bearings are located no more than 5 or 6 in. away from the engine whose case temperature is close to 1000°F. They must be lubricated with an extreme temperature range grease. Testing has led Boeing to use Shell's ETR Grease B.

Thrust reverser control bearings in one of the first production line 707 aircraft completed 305 hr of operation in an early test series without grease leakage or burn-up. There was also no increased friction in the reverser controls, lock-

THRUST REVERSER on Boeing 707 uses clam-shell doors, hinged top and bottom, to block normal exhaust flow. Bearings in this control system must operate at 450°F. Clamshell is shown closed in background.

CAM CONTROL for thrust reverser is located in engine pylon of 707. Bearings in this control mechanism are about 5 in. for case of Pratt & Whitney J-57 that reaches 1000° F in operation.

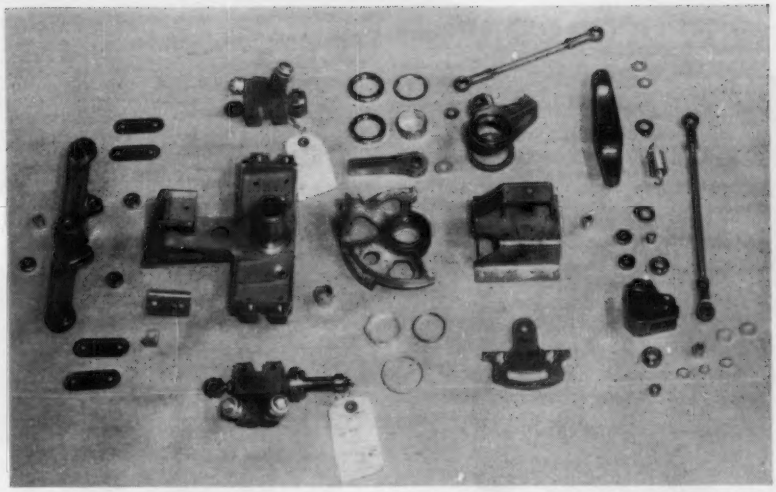
out or interlock mechanism. One set of bearings had been exposed to approximately 450°F temperatures for the 305 hr. Lubricating characteristics of the grease were still good. As a result, thrust reverser inspections probably will be held at 400 hr intervals

Reverser Design—The Boeing-designed thrust reverser is a cylindrical unit attached to the exhaust exit of the J-57 engine. Inside the cylinder are two steel clam shells which are positioned 180 deg apart on the periphery of the exhaust exit. The shells are vertically hinged top and bottom and can be rotated to a completely closed position. The cylindrical unit has large openings on each side. In the cruise position clam-shell doors are against the cylinder walls and seal the openings.

Located in each opening of the cylindrical unit are eight cascade cartridges. Each cartridge has many small vanes which direct the gases in the proper forward direction during reverser thrust. As the clam shells are moved to the reverser thrust position they close off the normal gas passage and rotate away from the side openings allowing the exhaust gases to flow through the side openings and be directed by the cascades.

Activation of the thrust reversers can begin only after the aircraft's wheels have touched the ground and the pilot has pulled the lever which causes the drag spoilers on the upper surface of the wings to pop up. Then the pilot pulls back on the thrust reverser levers of all four engines. These levers are halted at an interlock position and remain there until the thrust reversers are in complete reverse thrust position. At this point, the interlock mechanism is disengaged mechanically by the clam shell doors. This allows the pilot to continue pressure on the levers to obtain the reverse thrust required.

Bearings and Lubrication—Six different types of 440C stainless steel lubricated bearings are employed in the thrust reverser controls for a total of 15 per jet engine, 60 per plane. A portion of the thrust reverser control components (and therefore some of the bearings) are constantly in use since they are linked directly to the throttle system.



MOVING PARTS of thrust reverser controls lubricated with Shell's ETR Grease B are shown disassembled. About 60 bearings of 440C stainless steel are used on each Boeing 707. Torrington, Marlin-Rockwell, and Chain Belt are bearing manufacturers.

Two needle bearings act on a cam roller and move whenever the throttle is placed in either forward or reverse thrust range. An aircraft torque-tube (small race) bearing is used in 4 places on each engine. Two of them move at all times with the cam roller which is operated with the throttle cables. A 440C version of a standard AN201 bearing is used on the interlock arms and control valve operating arms; it oscillates about 20 deg and is activated only on reverse thrust. Another type of bearing is located at one end of the interlock arm. At each end of the control valve operating arms are bearings which have only 3 to 4 deg movement at low rpm, and serve to take out some misalignment of the push-pull motion in the control valves. A new type of rod-end bearing is used on the control valves. All bearings are packed with the extreme temperature range grease by the manufacturer before delivery.

Grease Testing— Selection of the ETR Grease B was not made until it had been thoroughly tested with other high temperature greases. These tests included:

(1) Thin film panel: Grease samples ⅛ in. thick were spread on a stainless steel panel and cooked for 4 hr at 600°F.

(2) Pope spindle: Number 204 bearings were greased and placed in a spindle traveling at 10,000 rpm with a 5 lb thrust and 15 lb radial load, at 565°F (average 70 hr).

(3) Oscillating: Greased K5 bearings were oscillated plus or minus 10 deg with a radial load about 10 percent of the bearing capacity, and operated at 565°F (average 100 hr).

Performance of this silicone/vat dye based grease under test and in actual operation in the thrust reversers shows its capabilities as a stepping stone to successful lubrication in high temperature areas in supersonic aircraft and missiles.

◆

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of this article can be obtained by writing on company letterhead to The Editor, AIRCRAFT & MISSILES, Chestnut & 56th Sts., Phila. 39, Pa.

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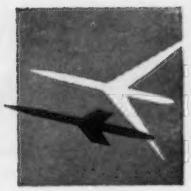
Circle 203 on Inquiry Card

New Materials



Hook-up Wire Operates at 1000°F

Mica and glass lead wire, known as Tetralene Type MGT, has been subjected to extensive heat-cycle tests without destruction to the insulation. It maintains minimum dielectric strength of 1000 volts. Wire has been successfully spark-tested at 2000 volts. Insulation resistance is maintained at above 10,000 megohms.—American Super-Temperature Wires.

Circle 106 on Inquiry Card for more data

"Dapon" Varnishes

Insulating and electrical properties of diallyl phthalate—already widely used as a molding material for electronic parts—can now be applied to coating, sealing, dip encapsulation, and laminating applications.

Cured "Dapon" coatings of the resin offer excellent resistance to moisture, chemicals, corrosive gases, fungus, weathering, and aging over a wide temperature range. They show particular promise for protective coatings on capacitors, resistors, and transformers.

Coatings are customarily applied by dipping the particular part in the resin solvent solution, drying, and baking for cure—Food Machinery and Chemical Corp.

Circle 107 on Inquiry Card for more data

Bearing Steels

New bearing steels offer improvements in properties over regular 440 C stainless steel.

First member of the family, Lesco BG 41, used in high temperature bearings and structural components in jets and missiles, is basically a replacement of 2% chromium in the 440 C analysis with 4% molybdenum.

The other members of the family, Lesco BG 42 and BG 43, consist of 1% and 2% vanadium, with corresponding higher carbon contents to the BG 41 analysis.—Latrobe Steel Co.

Circle 108 on Inquiry Card for more data

Teflon Sheet

High density pressure-molded Teflon sheet has high tensile strength, elongation and thermal dimensional stability. It exhibits extremely low void content due to unique processing methods. A new scientific annealing cycle assures excellent dimensional stability. Sheet sizes up to 24 in. x 24 in. and 2 in. thickness are available for immediate delivery.— Fluorocarbon Co.

Circle 109 on Inquiry Card for more data

Thermoplastic Resists Environmental Stress

New vinylidene fluoride resin, called Kynar, is designed for long life and high performance in environments which degrade less stable materials. Available as molding powder and pelletized resin for end item development and use.

Field trials have shown that Kynar is easily extruded and molded into many complex shapes using standard equipment. — Pennsalt Chemicals Corp.

Circle 110 on Inquiry Card for more data

Lubricant & Seal

Anti-seize sealing compound No. 250 can be used from subzero (—350°F) to extremely high temperature (2987°F.) It has been set up as a standard for assemblies of steam or gas turbines after 1400 hr tests at 1000° or better.— Armite Labs.

Circle 111 on Inquiry Card for more data

Plastic Foam

Re-useable plastic foam corners protect fragile items during transportation by land, sea or air. Corners will not "dust" or deteriorate, have a closed cell construction, excellent memory, and slow controlled rebound rate of recovery. Plastic foam is similar to polyethylene, but offers more protection and advantages than polyethylene, rubberized hair packs, polyvinyl chloride, styrofoam or polystyrene.—Pac-tron Inc.

Circle 112 on Inquiry Card for more data

Glass Cloth

Protection of equipment and personnel from high radiated heat is now possible with an aluminized silicone rubber coated glass cloth. This reflects more than 90 per cent of the infrared rays generated by a thermal source. In one application, electrical cable shielded with "Irvington" SRGA fabrics was placed 3 feet from a 2,300 to 2,800 degree F. jet exhaust blast. The cable remained operational after 25 seconds.—Irvington Div., Minnesota Mining and Manufacturing Co.

Circle 113 on Inquiry Card for more data

New Sealing Alloy

Fernico-5, an alloy primarily of iron nickel and cobalt, is now available for use in high density alumina seals.

Co-efficient of expansion closely matches that of high density alumina including translucent Lucalox up to the range of 600°C.

Oxidation resistance is good to 800°C. — Metallurgical Products Dept., General Electric Co.

Circle 114 on Inquiry Card for more data

continued on next page

New Materials

... continued

Anti-Friction Teflon Balls

Teflon is now being produced in spheres to meet exacting tolerance requirements of many critical anti-friction applications. Diameter and sphericity tolerances are maintained within .001 in.

High strength of balls is attained through use of 100% virgin Teflon powder.

Balls need no lubrication against friction due to resin's low coefficient of friction—0.04 against steel. Operating temperature range is from cregenic to above 500°F.—Tri-Point Plastics Inc.

Circle 115 on Inquiry Card for more data

Glass Cloth

New fiber glass cloth is designed for ease of laminating deep, sharp contour surfaces. Called Drapeze #391, it is .0283" thick, yet will form into and retain its position over a very sharp radius and deeply recessed area. Developed with the cooperation of Rohr Aircraft, Drapeze #391 replaces .030" and .014" thickness cloth which are difficult to form.—Rezolin, Inc.

Circle 116 on Inquiry Card for more data

Copper-Clad Laminate

Tellon 3A, a new copper-clad laminate designed for Nike Zeus, is now available. Intended primarily for micro wave and UHF printed circuitry. Completely isotropic, with low dielectric constant of 2.36± .01 and dissipation factor of .0002. Available in sheets to 14 x 18" with thicknesses from .020" to .125".—Military Electronics Div., Tell Mfg. Co.

Circle 117 on Inquiry Card for more data

New Alloy Used In Jet Brakes

NS-A286, an austenitic superalloy wire, has been adopted for return springs in aircraft brakes on the F4H-1 Mach 2 Navy Interceptor Fighter. Tests showed NS-A286 has high stress-temperature stability up to 1000°F.

When the brakes are released, springs must separate the stationary stator discs from the moving rotor discs. Heat in the stacks of discs can rise to 1400°F. The return springs are barely one-quarter inch from these hot stacks, shielded by a thin metal cylinder.

NS-A286 is a precipitation-hardening alloy made of 24 to 27% nickel, 13.5 to 16% chromium, 1.75 to 2.25 titanium, 1 to 2% manganese, 1 to 1.5% molybdenum, plus some silicon, aluminum, and vanadium.—National Standard Co.

Circle 118 on Inquiry Card for more data

PRATT & WHITNEY AIRCRAFT offers ENGINEERING OPPORTUNITIES in CONNECTICUT or FLORIDA

Noted for its 35 years of engineering achievement in the power and propulsion field, Pratt & Whitney Aircraft is expanding its operations in advanced research and development projects and long-range product planning. This expansion has created openings at all levels of experience for engineers and scientists who can become part of a team dedicated to maintaining Pratt & Whitney's position of leadership in the future.

ADVANCED PROJECTS GROUP

For new research and development projects and long-range product planning in the fields of propulsion and power systems and their applications. Work involves performance and optimization studies of all types of advanced powerplant systems including stationary, marine, aircraft, missile and space craft applications.

SPECIFIC OPPORTUNITIES

- Aero Thermo Engineers—to study supersonic and hypersonic air-breathing propulsion for aero space craft.
- Aero Engineers—to study advanced subsonic and supersonic aircraft and space craft system performance.
- Power System Engineers—to study nuclear, chemical, and direct conversion systems for propulsion and satellite power.
- Nuclear Engineers—to work with advanced concepts in reactor systems and components.
- Applied Science—PhD level for work in solid state physics, gaseous phenomena physics and applied mechanics.

DESIGN ENGINEERING

Engineers to engage in the mechanical design of propulsion systems, including turbojet, turbo fans, solid rockets, liquid rockets, magneto-hydrodynamics, nuclear and fuel cell power applications.

ANALYTICAL ENGINEERING

Engineers with experience in the analysis of propulsion systems design, including the fields of advanced structures, stress analysis, vibrations, compressor analysis, turbine analysis and combustion or heat transfer.

Please submit your complete resume, including minimum salary requirements to:

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410 MAIN STREET
EAST HARTFORD 8, CONN.

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MR. J. W. MORTON, OFFICE 40
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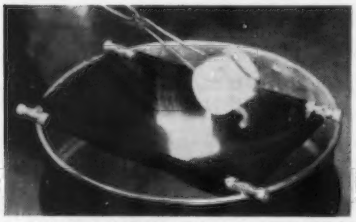
PRATT & WHITNEY AIRCRAFT
DIVISION OF UNITED AIRCRAFT CORPORATION
EAST HARTFORD 8, CONNECTICUT

Circle 204 on Inquiry Card

Heat-resistant Fiber

All-organic heat-resistant fiber retains flexibility and part of its strength after exposure to intense heat.



Called "Pluton," it is available as a fabric. Pluton can also be worked into laminates reinforced with high-temperature phenolic resin to form structural parts or molding compounds. Fiber is entirely free of elemental carbon and conducts very little heat or electricity. It does not char or melt.

Potential uses are missile motor case liners, insulation for drag-chute compartments in high-speed jet aircraft and missile structural parts.—Minnesota Mining and Manufacturing Co.

Circle 119 on Inquiry Card for more data

Dacron Felt

Troyfelt, a non-woven Dacron felt, is being used to prevent corrosion of helicopter battery racks. It acts as a blotting material which absorbs spilled battery acid without deteriorating.—Troy Blanket Mills.

Circle 120 on Inquiry Card for more data

Teflon Rod Seal

Rod seal is formed from Viton and protected by a backup washer of carbon-impregnated Teflon. It reduces cost and time for cylinder maintenance and replacement. The combination, trade-named "Duraton," maintains a resiliency during continuous cylinder operation at 400°F and higher. — Hydro-Line Manufacturing Co.

Circle 121 on Inquiry Card for more data

Ceramic Fiber

Fiberfrax ceramic fiber, a high temperature insulation, has completed pilot plant production and field testing. It is now classed as a standard product of firm's Refractories Div.

A mix of high grade alumina and silica sand is heated to 3900°F and poured in a molten stream the size of a lead pencil. The stream is struck with a blast of air or spun into fibers of varying lengths that look very much like white wool. The light, durable material withstands continuous operating temperatures up to 2300°F.—The Carborundum Co.

Circle 122 on Inquiry Card for more data

Chemical Approach to Anti-Icing

Chemical additive prevents in-flight ice formation in aircraft jet fuel systems. Compound, called PFA 55MB, is available for jet aircraft and guided missiles using jet fuel. The Air Force recently approved its use by the Strategic Air Command.—Phillips Petroleum Co.

Circle 123 on Inquiry Card for more data

■ There are many applications in both military and commercial transportation for Visioneering's famous undercarriage systems. The standard unit you see pictured above is supreme in its field.

Wherever delicate instruments or fragile cargo are to be hauled over rough terrain at high speed, you'll see this type of "Cushion Ride" undercarriage. In Nike installation vans and other ground support equipment you'll find these undercarriages protecting fire-control and missile loading equipment, as well as missile hauling and communications systems.

If you are developing a towed van or trailer of any type for transporting loads which will require maximum protection from road shock, our engineers will be happy to show you the advantages gained by using Visioneering-designed undercarriage units. We make a wide variety for every possible load and terrain requirement.

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SHOCK TRAP® for WATER LINES

Eliminate water hammer and pipeline bursting. Save piping and plant costs with guaranteed surge limits.

PATENTS PENDING

PULSCO®

Designed primarily for shut-down or shut-off application, this unit is used in pumping plants, irrigation systems, fire control on rocket test stands, municipal water systems, etc. Of the water interface type, the Pulsco swirl principle reduces pressure and reduces shock and surge resulting from kinetic energy within the pipeline, this by compressing gas within the chamber and by friction through the swirl chamber.

Guaranteed not to recycle, this Pulsco Spherical Shock Trap is built for pressures to 200 PSIG and up. Sizes from 34 to 102 inches diam.

PULSCO *Bellows* SHOCK TRAP

For AIRCRAFT AND MARINE FUEL LOADING SYSTEMS JET FUEL AND GASOLINE

Take the "hammer" out of high velocity fuel lines — removes the danger of broken lines, meters, and overstressed loading equipment. Assure correct meter readings consistently with this Pulsco scientifically designed Bellows Shock Trap — the best for quick STOP and GO liquid lines.

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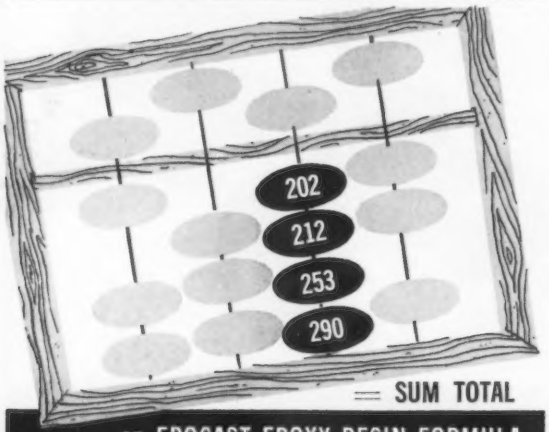

an EPOCAST EPOXY RESIN FORMULA for any ELECTRICAL INSULATION PROBLEM!

More than 30 different formulas are now in stock to solve your electrical insulation problems. Whether it be an extreme environmental condition or a normal impregnation, encapsulation or coating project, there's a Furane epoxy resin to fit your requirements.

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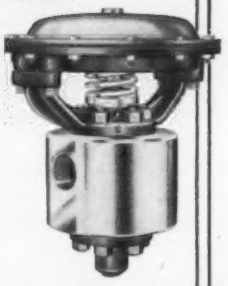

For more information, write for Bulletin SC-59. Address The Sinclair-Collins Valve Company, Akron 9, Ohio, Dept. AIM-261.

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FOR **AIRBORNE & TEST CELLS**

- Precision and regulation, to 3°F or better by multiple temperature controls.
- 24 volts AC or DC or 115 Volts AC, DC less than 50 watts.
- It offers field adjustable or fixed reference temperature with built in resistance temperature monitor.
- From 5 to 30 circuits in any standard combination of thermocouple wire.
- Warm up time ½ hour at —65° F.
- Environment: MIL-E-5272A.
- Ambient of —65 to +200°F causes less than 3°F change in control temperature.
- Can be rack mounted for test cell operation.

VSMF—Reel F

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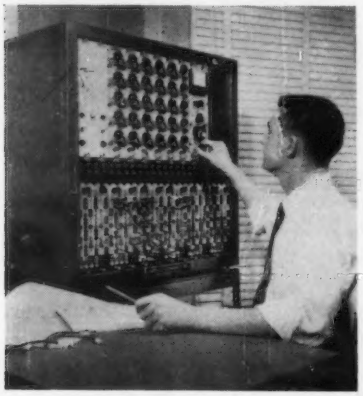
Sales Representatives throughout the United States and Canada

Circle 14 on Inquiry Card

New Electronic Products

Analog Computer Used In B-70 Program

Desktop analog computer is being used for electronic simulation of the B-70's anticipated performance under various landing conditions.



Called the AD-1, this computer can be expanded to 32 amplifiers for desktop use and 64 amplifiers as a floor console. Continuous report is recorded by a stylus and chart.—Applied Dynamics Inc.

Circle 124 on Inquiry Card for more data

Plastic Protectors

Plastic protectors safeguard miniature rectangular, electronic connectors during manufacture, shipment, storage, and use. Protection in use is perhaps its most important function. The new close-fitting caps also keep out moisture, dust and contamination.—S. S. White Industrial Div.

Circle 125 on Inquiry Card for more data

Switching Module

Self-contained switching module reduces cost of life-testing semiconductor diodes and rectifiers. Designated Model 180, each is capable of switching 20 amp average DC at up to 1500 PIV. Output consists of 20 one amp circuits in a full-wave configuration or 10 one amp circuits per half wave.—Wallson Asso.

Circle 126 on Inquiry Card for more data

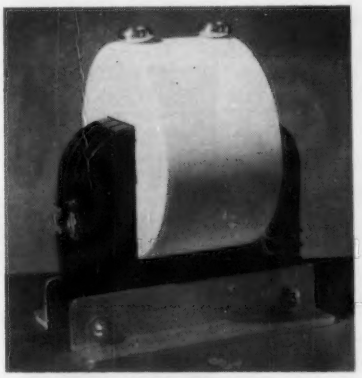
Time Delay Relay

Packaged adjustable time delay relay includes four different timing ranges. Designated Model T-164, relays are available in four contact arrangements and two different mounting styles.—General Automatic Corp.

Circle 127 on Inquiry Card for more data

Transformers

High-voltage specialty transformers are available in a new series



of designs that feature complete encapsulation of the windings in epoxy resin. Filament, isolation, and high-voltage supply transformers and reactor chokes are being produced in proved designs over the voltage range from 15 to 6,000 va and with isolation to 300 kv.—Components for Research Inc.

Circle 128 on Inquiry Card for more data

Acceleration Switch

Acceleration Switch is designed for low milli-g-range. It closes a circuit when a given acceleration is applied. Gas damping provides the

proper time delay or integration before switch closure. Unit meets shock, vibration, temperature, and other environmental requirements of MIL-E-5272C, and is designed to operate accurately in the low "g," high temperature range.—Kearfott.

Circle 129 on Inquiry Card for more data

D-C Amplifier

Instrumentation amplifier is designed for use with interchangeable plug-in input circuit modules. It can be operated in various combinations of fixed or variable gain or bandwidth. Amplifier may be manual or remote controlled.

Designated Model 361, it has bandwidth of 100 kc, which is unaffected by gain changes. Common mode rejection ratio of the amplifier is said to increase in direct proportion to increase in amplifier gain. The cmr is 1,000,000 between dc and 150 cps. Input impedence at dc is at least 1000 megohms. — Packard Bell Computer Corp.

Circle 130 on Inquiry Card for more data

continued on next page

HUCK fasteners are the answer

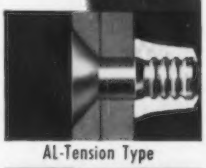
Whether you want dependable strength under intense heat or speed of application for a "hot" production schedule,you can get either or both with Huck aircraft fasteners.

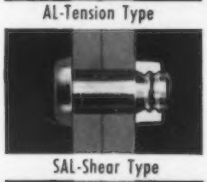
Huck standard or specially engineered fasteners are a dependable part of practically every craft plying the airways of the world or orbiting the globe.

These fasteners, specially engineered for aircraft use, are available in sizes, grips, headstyles and metals to meet your needs.

Huck fasteners are easily installed up to thirty per minute with complete uniformity of tensile preload. Installed savings up to seventy per cent of former fastening methods have been accomplished.

We invite your inquiries.


AL-Tension Type


SAL-Shear Type

MLS-Mechanical Lock Spindle

MS-Blind Rivet

BL-Blind Huckbolt

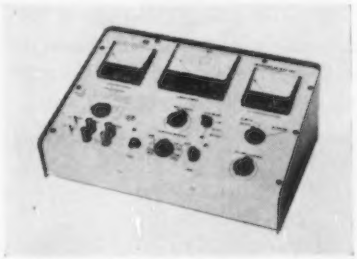
HUCK MANUFACTURING COMPANY

2480 Bellevue Avenue • Detroit 7, Michigan • Phone WA 3-4500

New Electronic Products

Transistor Tester

Instrument measures basic parameters necessary to check a transistor's performance.

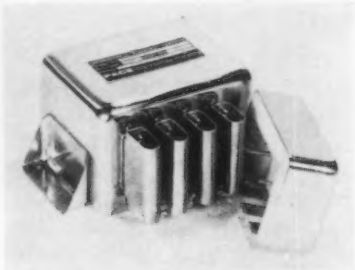


No special connections or time-consuming adjustments are required. Transistors are plugged into the unit. Each test is made by positioning the function switch. Results are read directly from a meter.—Armour Stablvolt Div., Magnetic Research Corp.

Circle 131 on Inquiry Card for more data

Temperature Reference

Miniature thermocouple reference junction is for in-flight applications. It provides a precise temperature reference for multi-channel thermocouple systems with minimum space, weight and power consumption.

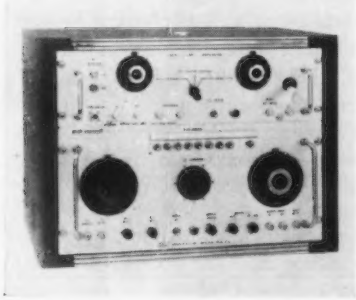


Instruments operate on 105-125 volts, 380-420 cps. They meet environmental requirements MIL-E-5272 for acceleration, vibration, altitude and humidity operation over an ambient operating temperature range from —65°F to +165°F with less than ½°F reference temperature variation.—Pace Engineering Co.

Circle 132 on Inquiry Card for more data

Determines VSWR and Attenuation

Test instrument determines VSWR and attenuation values of RF components or circuits. Set uses a pair of coaxial switches operating at 30 cps to produce a dual oscilloscope trace. The two traces, representing a reference value and an unknown, provide instantaneous readings of VSWR or attenuation for the device under test. In operation, the unknown device is connected to the proper terminals on the test set producing a trace of undetermined value on the scope. The VSWR or attenuation dial is then

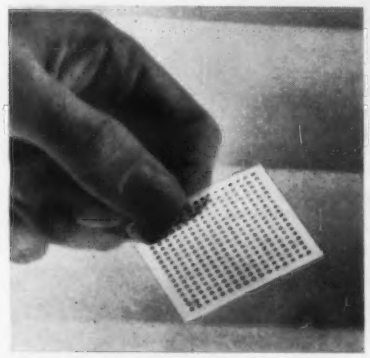


rotated to obtain a response on the scope that matches the trace of the unknown.—Telonic Industries Inc.

Circle 133 on Inquiry Card for more data

Thin-Film Memory for Advanced Computers

Thin-film computer memory reportedly makes possible a whole new



generation of computers that operate in manoseconds, billionths instead of millionths of a second. It consists of a series of metal dots, a few millionths of an inch thick, made by depositing vapors of iron, nickel, cobalt, or other ferro-magnetic metals or their alloys, on a suitable substrate, such as a thin glass plate.—Remington Rand Univac Div.

Circle 134 on Inquiry Card for more data

Testing Components

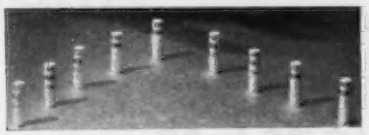
Two new automatic component test systems are designed for semi-automatic testing of large numbers of individual resistors, capacitors, diodes, and zener diodes. The systems provide punched card records of changes in component values with time.

Components to be tested are mounted on etched circuit boards which are inserted into the test sets. The desired measurements are then made automatically in accordance with a programmable operating sequence to provide desired data.—Dymec, Div. of Hewlett-Packard Co.

Circle 135 on Inquiry Card for more data

Mixer Diodes

Matched pair of high altitude silicon microwave mixer diodes are designed for use in ultrasonic aircraft and missile applications.



Hermetically-sealed, diodes are Ka-band (34,000 mc) units with maximum operating temperature of 150°C, overall noise figure of 9.0 db, and an amplifier noise figure of 1.5 db.—Sylvania Electric Products Inc.

Circle 136 on Inquiry Card for more data

continued on next page

Classified Advertisement

FASTENERS FOR AIRCRAFT AND MISSILES
Immediate Delivery—AN—N.A.S.—M.S.—6 Digit
CERTIFIED TO GOVERNMENT SPECIFICATIONS
Bolts—Nuts—Rivets—Screws—Studs—Internal and External Wrenching Bolts—Dowel and Lock Pins
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Circle 16 on Inquiry Card

SILICONE NEWS from Dow Corning

Photo courtesy Fairchild Engine & Airplane Corporation

Seals Where Others Failed

Fairchild recently supplied several F-27B's to Northern Consolidated Airlines, which serves Alaska and Canada. Trouble started when temperatures dropped below —50 F. Seals caused doors to stick closed. After the doors were opened, seals were so hard the doors couldn't be closed. Silastic®, the Dow Corning silicone rubber, was used to replace the seals for the large cargo and passenger doors. Results: no sticking closed, no jamming open . . . Silastic maintains a positive seal at all altitudes despite the wide variations in temperatures encountered.

Write to Dept. 0314 for information.

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

Circle 17 on Inquiry Card

New Electronic Products

. . . continued

AC/DC to DC Comparator

The AC/DC to DC Comparator is a precision summer-limiter-amplifier-limiter based on operational amplifier techniques. Peak ac may be compared to dc with .005 per cent comparison accuracy, dc to dc to .001 per cent. In addition to calibrating ac and dc standards, comparator makes possible precision observation of small selected portions of large waveforms without oscilloscope overload. Unit is completely transistorized. — Rotek Instrument Corp.

Circle 137 on Inquiry Card for more data

Arming Switch

Model EL-1091 arming switch is designed to prevent accidental circuit actuation caused by power transfer under launch conditions (transients, surge, and spikes). The affected circuits are then armed after a predetermined elapsed time. Model, with or without time delay,

has still other interesting applications, such as maximum velocity sensing and control, constant speed control. It is well suited to inertial programming in general.—George Harmon Co.

Circle 138 on Inquiry Card for more data

Wavemeters

Series of three broad-band absorption type wavemeters features high reliability and direct readout in low cost standard units. Full coverage from 1 to 8 kmc. Accuracy of 0.07% plus the added convenience of direct frequency calibration. Readout device consists of a high precision film driving mechanism with virtually no backlash.—Frequency Standards.

Circle 139 on Inquiry Card for more data

Rectifier

Half-wave, high vacuum rectifier tube is designed to operate in installations subject to shock and vibration as well as filament fatigue. Filament voltage is 2.5V at 3.0 amp AC. Peak inverse voltage is 20KV. Peak plate current (ib) is 300MA (Filament 5.OV). The 3B24WA has a 4 prong base and a shock rating of 450G. — Cetron Electronics.

Circle 140 on Inquiry Card for more data

Mechanical & Aeronautical Engineers

Design & development opportunities in engine components, controls, and accessories for the entire jet spectrum . . .

The CJ-805 for the Convair 808 . . . T-58 turboshaft for helicopters and VTOL aircraft . . . J-79 for the B-58 *Hustler* . . . these are only a few of the achievements of General Electric's Flight Propulsion Division.

Current projects, both military and commercial, are aimed at creating next-generation systems throughout the power spectrum of turboshaft and turbojet engines – for unusual lift fan systems for VTOL/STOL to the J-93 for the world's first Mach 3 bomber, the B-70 *Valkyrie*.

Experienced ME's and AE's are invited to inquire about the excellent positions now available in the following areas:

COMPONENT DESIGN ENGINEERING – advanced design work on jet engine components, compressors, turbines, structures, etc. (0-5 years experience).

CONTROLS & ACCESSORIES – design and development of electromechanical control devices and systems, gears, linkages, cams, servos, etc. (3-8 years experience).

PERFORMANCE ANALYSIS – plan engine and component tests on statistical basis, issue performance test project sheets, analyze test data (3 or more years experience).

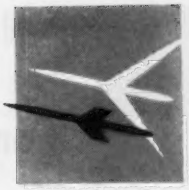
Write informally, or forward your resume in professional confidence to: Mr. Mark Peters, Dept. 125-MB

FLIGHT PROPULSION DIVISION

GENERAL ELECTRIC

CINCINNATI 15, OHIO

New Parts and Components



Indicator Light

Moistureproof subminiature indicator light meets shock tests of MIL-S-901B. It is being used in missile launching control equipment and military aircraft. Rated for a minimum of 60,000 hours of operation at 5v. and a minimum of 6,000 hours at 6.3v. — Control Switch Div., Controls Co. of America.

Circle 141 on Inquiry Card for more data

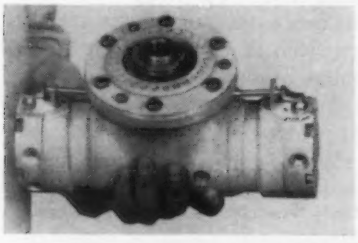
Lightweight Mirrors

Optical mirrors for airborne systems five to ten times lighter than conventional optical parts are now available. Honeycomb cross-section achieves the weight-saving. Recommended for shock-resistant applications, mirrors can be furnished as flats, spheres or aspherics in diameters up to 48 inches. These glass or quartz units will withstand all standard environmental conditions. They can be supplied with suitable mountings.—Precision Lapping Co.

Circle 142 on Inquiry Card for more data

Engine Propels Underwater Missiles

New engine weighs only 17.3 lbs. It can deliver 20 hp, and will permit underwater missiles to operate at deep depths for long periods of time.



Engine reportedly has the lowest specific fuel consumption ever achieved for engines of this general type.—Avien Inc.

Circle 143 on Inquiry Card for more data

Tape Recorder

Magnetic tape recorder measures only 2″ by 4″ by 5″, weighs 31 oz. (including 7 oz. of tape.)

Designed for direct recording of dynamic data in the range from 100 cycles to 5000 cycles. The

PS-303M can also be used in conjunction with standard IRIG telemetry sub-carrier oscillator equipment for multiplexing up to 30 channels of data in the range from d-c to approximately 100 cps. It requires ¾ of a watt of power.—Precision Instrument Co.

Circle 144 on Inquiry Card for more data

Self-Aligning Locknut

Self-aligning locknut develops full-rated strength of aircraft bolts even though the seating surface is as much as 8° out of perpendicular to the shank.

Compensating fastener consists of a hex drive SPS featherweight series self-locking nut which swivels within the spherical seat of a precision alignment washer.

An exclusive design maintains constant bearing area between alignment washer and nut from 0 deg. to 8 deg.—Standard Pressed Steel Co.

Circle 145 on Inquiry Card for more data

Eliminates Most Tubes In Cooling Systems

Liquid cooling system is for airborne electronics in a counter measure system. Pack has a nominal combined rating of 1,000 watts dissipating capacity. It is designed with semi-independent dual coolant flow paths to control the temperature of both receiver and transmitter of the ECM system. To conserve size and weight, and to increase reliability, all pumping system components have been designed into a single case manifold assembly.—Eastern Industries Inc.

Circle 146 on Inquiry Card for more data

Electric Power Supply

Electric power supply is for primary, auxiliary, or emergency applications. Hydraulically-driven, it delivers 3 KVA, 3 phase power at

400 cps, for continuous duty into a balanced load. A full 1.5 KVA is supplied at a continuous load unbalance of 20 per cent.

Featuring a self-contained electro-hydraulic on-off speed control, this power system delivers a regulated output that is superior in performance to stepless control systems.—Walter Kidde & Co.

Circle 147 on Inquiry Card for more data

continued on next page

New Parts and Components

. . . continued

Linear Accelerometer

Sub - miniature non - pendulous constant-damped linear accelerometer weighs less than three ounces and is slightly under one cubic inch

in volume. It provides independent control of natural frequency for any given G-range, and is the first accelerometer of its size providing non-pendulous motion, frictionless suspension and constant positive displacement damping over a wide temperature range.

Control of the natural frequency is achieved through use of variable area fluid coupling. Instrument is ruggedly designed for stabilization or autopilot applications.—Minneapolis-Honeywell Regulator Co.

Circle 148 on Inquiry Card for more data

Hot Gas Relief Valve

New concept in missile hot gas pressure relief valves for liquids and solid fuel exhaust systems has been developed. Design incorporates replaceable metal seat which is pressure tight up to 2000°F. Very low hysteresis. A typical design cracks, permits full flow, and reseats all within 50 psi in 1000 psi—2000°F exhaust system.—General Pneumatics Corp.

Circle 149 on Inquiry Card for more data

Flo-Ball Valves

Industrial Flo-Ball valves feature top entry for easy maintenance, and Teflon seats and seals. Removal of bonnet flange permits easy access to the ball and seats without removing the valve from the line. Valve is simply installed much the same as a spool piece. It is the only ball valve with an external provision for seat adjustment by simply tightening two hex nuts on the bonnet.—Hydromatics Inc.

Circle 150 on Inquiry Card for more data

Thermocouple Probes

Thermocouples are designed to measure temperatures from 2000°F to 4000°F. They are available in tungsten/tungsten 26 per cent rhenium; iridium/iridium 40 per cent rhodium and platinum 13 per cent rhodium/platinum.

Insulation is MgO or BeO. Wire and insulation are contained in a sheath of tantalum, molybdenum and platinum.

Probes can operate at 3200°F in an oxidizing atmosphere through use of long life coatings on molybdenum.

Applications include hypersonic vehicles, jet afterburners, rocket combustion chambers.—Aero Research Instrument Co.

Circle 151 on Inquiry Card for more data

Miniature Turbine

Expansion turbine is less than three in. long. It is for use as a cooling unit in air liquefaction apparatus, allowing air or any other gas to be cooled without contamination by lubricants.

Bearings in the unit are of the externally-pressurized type. Each consists of a sleeve with 6 injector holes and 6 pairs of stabilizer holes. Air diverging from each injector hole flows into the adjacent pairs of stabilizer holes and escapes via the cavities and outlet orifices. Each cavity and orifice acts as a pneumatic phase shift network which rapidly damps any accidental oscillation of the shaft.—British Oxygen Research & Development Ltd.

Circle 152 on Inquiry Card for more data

Integrating Rate Gyro

Integrating rate gyro, model LG01, incorporates a special damper for integrating the angular rate and a caging solenoid for holding the instrument in null position before use. It can be economically applied in any free gyro application where output on only one axis is required and unlimited rotation is not required. Model covers a range of +60°, –40°.—Humphrey Inc.

Circle 153 on Inquiry Card for more data

Cooling System

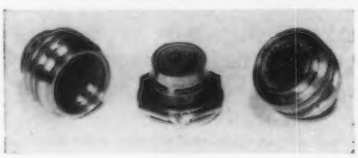
Cooling system for airborne electronics utilizes a patented constant torque magnetic coupling used as a component of a blower assembly. At sea level, system requires 380 watts input from 115/208 volts, 400 cycle, 3 phase aircraft power supply. Pack weighs nine lb and measures 7 in. by 7 in. by 5 in. —Eastern Industries Inc.

Circle 154 on Inquiry Card for more data

Hermetic Plug

Hermetically - sealed connector incorporates socket-type contacts. The contacts are of the closed entry type with a hooded spring. This insures constant spring tension and wiping action under extreme operating conditions. Both eyelet and solder cup contact terminations are provided.—The Deutsch Co.

Circle 155 on Inquiry Card for more data



Tube Samples Ultraviolet Radiation

Electronic imaging tube, placed on a vehicle in space, will respond to short-wave ultraviolet light rays emitted by celestial bodies. Called the Uvicon, tube will be used in NASA's Orbiting Astronomical Observatory program (OAO).

It has two inch diam, is twelve in. long and weighs about eight oz. Back surface of the window is coated with a photo-emitting material that releases electrons when the ultraviolet image strikes it. These electrons are accelerated by 15,000 volts toward the rear end of the tube, where they strike a thin film or target. — Westinghouse Electric.

Circle 156 on Inquiry Card for more data

Rate Gyro

DC rate senor regulates, inverts and feeds a 28 VDC input to an AC gyro motor and pickoff. Output of the microsyn-type pickoff is then demodulated, balanced, gain-adjusted and filtered, providing DC output up to 12 volts is below 0.05%. Package has withstood 30 g vibration up to 2000 cps. Other critical specifications include: temperature, 0° to +185° F; constant damping coefficient within ±0.15% of nominal; linearity, 1.0% of maximum rate; zero calibration, 0.01 to 0.02% of maximum rate; life 500 hrs. minimum.—R. C. Allen Aircraft Instrument Div.

Circle 157 on Inquiry Card for more data

Counters

Improved readability for below-eye-level instruments is provided by a new series of precision counters.

Maximum figure representation results from removal of transfer pinions from an exterior location to within the unit. This allows larger

continued on next page

tailor line power to fit your needs

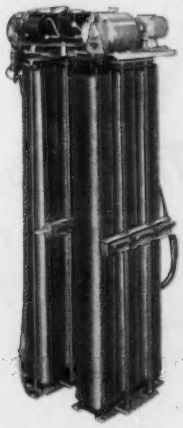
GLENN PACIFIC
INDUSTRIAL POWER SUPPLIES

HERE'S HOW...with a GLENN PACIFIC power supply, you can convert your existing single, two or three-phase ac line power into:

- Any desired voltage—fixed or continuously variable.
- AC or dc output.
- Any volt-ampere curve characteristic—constant current, constant voltage, or reactive to any degree you want.

LINE COMPENSATION VOLTAGE REGULATOR for radar station accepts 3-phase, 208v ±10%, delivers 3-phase 208v ±1% at 300 amp., with non-distorted sine wave at all settings. Rated at 108 kw, 100% duty cycle, convection cooled.

ELECTROLYTIC CAPACITOR FORMING power supply provides continuously-variable dc output from 0 to 415 volts, 300 amperes. Input is 230/460 v 3 phase. Other units available with 0-250 v output. Many of these GLENN PACIFIC units are used by leading capacitor manufacturers.



VARIABLE VOLTAGE transformer used in laboratory power supply delivers 0 to 460 v ac at 200 amperes; operates from 3 phase 208/230 v input.

WHAT'S YOUR PROBLEM? Need a dc source for motor drive and speed control—for powering laboratory or production line dc magnets, instruments, test stands—for electroplating, electrolytic refining, etching, de-tinning? You'll be hours and dollars ahead to contact GLENN PACIFIC; please address Dept. 184.

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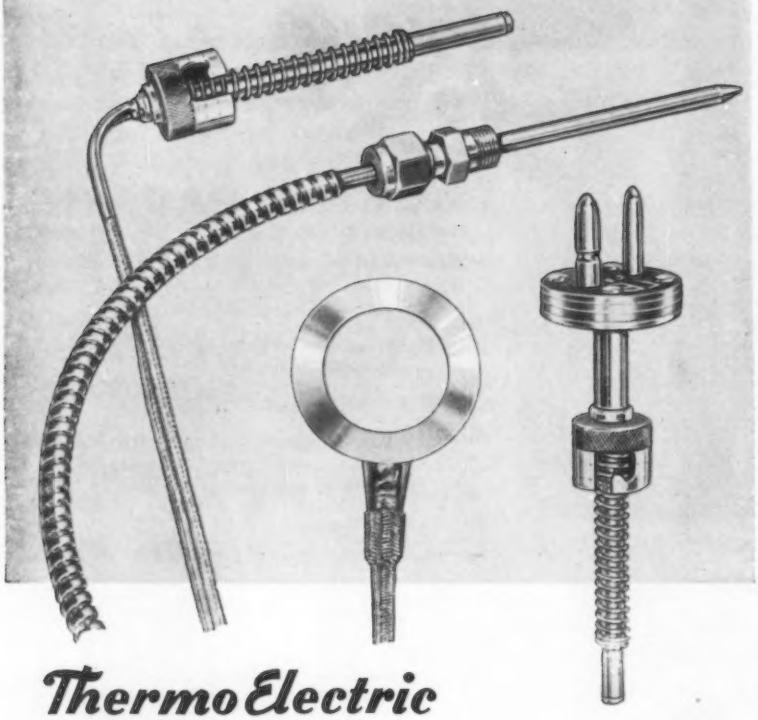
MID-WESTERN OFFICE
640 South York Elmhurst, Illinois

Circle 20 on Inquiry Card

Peak Performance—
economy on the job!



Thermo Electric
Miniature Thermocouples

You can obtain a Thermo Electric Miniature Thermocouple for peak performance and economy in almost every application! Those illustrated are available in a wide variety of sizes, standard thermocouple materials, adapt to many applications.

Protected thermocouples are extremely sensitive, give fast response to minute temperature changes. The measuring junction is welded or silver soldered to the tip of the thin-walled "Ceramo" metal sheath. Ideally used in corrosive liquids or gasses—and many pressure applications. For quick-coupling versatility, the spring-loaded bayonet-lock thermocouple is tops! You can use one "couple" at various depths with different adapters. With spring-loading, tip contact is always maintained. The bayonet type is highly sensitive, fast responding, for use in pump and engine cylinder heads, turbine housings, pipes, electric motors, generators, plastic extruders and molding machines.

Gasket Thermocouples measure surface temperatures in all sorts of stationary or moving machinery.

T.E. also produces stagnation, exposed junction and shielded thermocouples for use in air, gas or vaporous atmospheres.

write today for Bulletin **1256-1**

Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY

In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

New Parts and Components

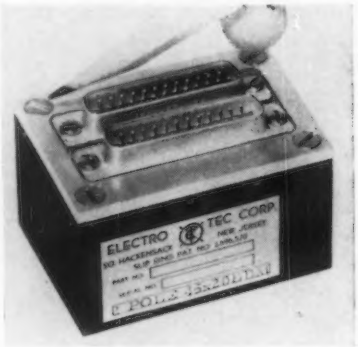
. . . continued

number wheels. Counter has a .220 high figure in a .305 opening. Designed for navigational or directional systems, as well as for laboratory equipment.—Veeder-Root Inc.

Circle 158 on Inquiry Card for more data

Missile & Satellite Telemetering Switch

Microminiature telemetering switch provides up to 450 channels in various combinations of circuitry. Switch measures 1⅜ in. x 1⅜ in. x 2½ in. Design features provide operating life expectancy well beyond 1000 hr. Unit enables combinations of circuitry up to a maximum of 5 poles with 90 channels per pole. Motor-driven device



operates at standard speeds from 1-20 RPS utilizing a drive motor drawing 60 ma at 28 volts DC. Weight: 8 oz.—Electro-Tec Corp.

Circle 159 on Inquiry Card for more data

High Voltage Connector Series

New series of small, threaded high voltage connectors are of BNC size but feature positive thread coupling. Connectors can operate at 7500 Volts RMS, 60 cycles at sea level. They accommodate RG-59, 62, 71 or equivalent high voltage cables. Impedance is 50 ohms.—General RF Fittings Inc.

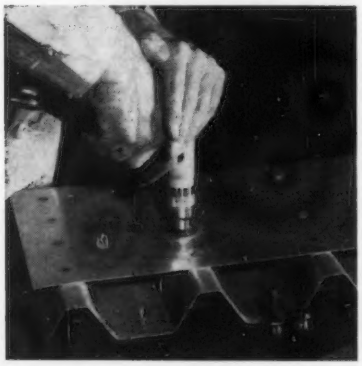
Circle 160 on Inquiry Card for more data

New for Production

Spot-Welding Torch

Improved-hand held Argonarc spot welding torch is being introduced.

Process is semi-automatic and



requires only semi-skilled labor. Only occasional changing and resetting of the tungsten electrode is required. A good surface finish can be obtained, usually without subsequent grinding and polishing to give a good surface.

Water-cooled torch can carry currents up to 250 amps. Interchangeable nozzles allow it to be used for making spot welds on horizontal or vertical surfaces, narrow flanges or even on 90° outside corners.—British Oxygen Gases Ltd.

Circle 161 on Inquiry Card for more data

Process Control

Multi-point temperature controller provides accurate automatic two-position control for up to ten separate processes.

Instrument can also be used as a single point controller, a five-point three-position controller and a manual-balance indicator. Any points not being used for control of a multiple-temperature process can monitor other processes.—Thermo Electric Co. Inc.

Circle 162 on Inquiry Card for more data

New Console-Type Ultrasonic Cleaners

Console type ultrasonic cleaners are designed for laboratories and "clean rooms." Models are available with one, two and three chambers.

All controls are mounted on the sloping front panel. Working cabinet height is either 30″ or 36″.

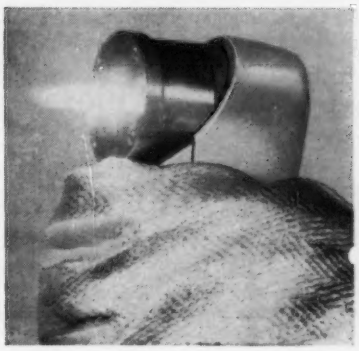
In the two-chamber console, designed primarily for use with solvents, the right-hand chamber is used for the cleaning operation, and the left chamber for a spray rinse. The third chamber of the three-chamber console, which is designed for water-based cleaners, contains a forced-air heater to dry the cleaned parts.—National Ultrasonic Corp.

Circle 163 on Inquiry Card for more data

Arc-Plasma Spray Gun

Arc-plasma hand spray gun is less than 2″ long and 1½″ in diameter. It weighs less than 1 lb., makes possible the spraying of materials onto previously inaccessible surfaces. Gun has sprayed corrosion-resistant and high temperature coatings on the interior walls of small rocket nozzles, cylinders and chambers.—Plasmadyne Corp.

Circle 164 on Inquiry Card for more data



Automated Welding

Single-station rotary welding machine automatically welds a ring gear to a hub in the fabrication of flywheel assemblies. It is easily adaptable to accommodate different types and sizes of flywheel assemblies through interchanging of tooling. Continuous running cam drive can be used in the machine to index the flywheel assembly through numerous welding operations.—Expert Welding Machine Co.

Circle 165 on Inquiry Card for more data

Automatic Viewer Welding Helmet

New type helmet allows welder to look at his work without touching his welding helmet. His chin

does the job. Whenever the welder wants to see his work, he simply opens his mouth. To automatically replace his leak-proof light filter, he closes his mouth. A spring-activated mechanism in the welding helmet does the work.—Auto-View Welding Helmet Co.

Circle 166 on Inquiry Card for more data

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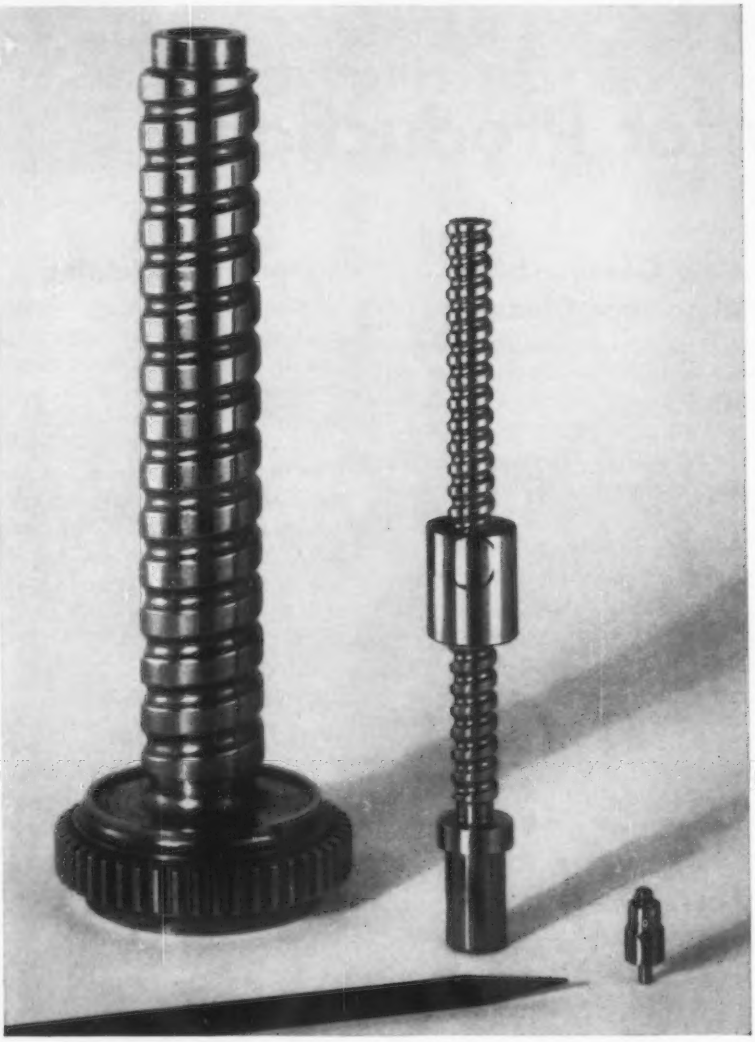
PERFORMANCE · RELIABILITY · COMPACTNESS · PRECISION



Kidde Ballscrews now in production include these ranges:

SIZES—3/16 to 1¼ inches (dia.), 19/32 to 8 inches (thread length).
WORKING LOAD—30 to 2000 lbs.
TEMPERATURE—minus 65°F to plus 840°F.
PRECISION—lead error of 0.0003 inch/ft.

Kidde ballscrews have a minimum amount of backlash and friction, perform functions demanding rapid reversibility of heavy loads. These abilities make them suitable for an extremely wide variety of applications in aircraft, missiles, and ground support equipment, including their use in aerodynamic surface controls, steering mechanisms, nuclear scram rod controls, and radar scanning drives. For more information ask for Brochure A-28.

Kidde

Kidde Aero-Space Division

Walter Kidde & Company, Inc., 280 Main St., Belleville 9, New Jersey

District Sales Engineering Offices: Boston, Mass. • Dallas, Texas • Dayton, Ohio • Huntington, L. I., N. Y. St. Louis, Mo. • San Diego, Calif. • Seattle, Wash. • Van Nuys, Calif. • Washington, D. C. Walter Kidde-Pacific, Van Nuys, California • Walter Kidde & Company of Canada Ltd., Montreal, Toronto, Vancouver

The words 'Kidde', 'Lux', 'Inflatair' and the Kidde seal are trademarks of the Walter Kidde & Company, Inc.

New for Production

. . . *continued*

Dual-Roller Floturn

The No. 70 horizontal dual-roller Floturn machine has been designed and built to form cylinders 70″ in diameter and 84″ long. Because of the design of the machine, it is possible to back-flow cylinders up to a maximum length of 140″ and beyond, depending upon tooling and production techniques.

Although principally intended for the flowing of cylindrical shapes, the No. 70 Horizontal Floturn is also capable of forming contoured and conical parts which may also be required in missile production. The

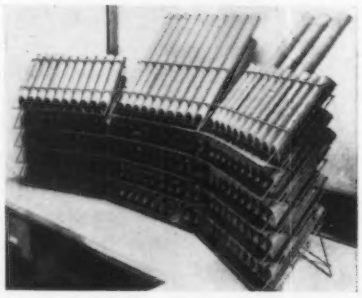
parts will be produced from flat or pre-formed blanks. Workpieces may be mild steel, stainless steel aluminum, brass or other alloys.—Lodge & Shipley.

Circle 167 on Inquiry Card for more data

Feeds Pre-cut Wires

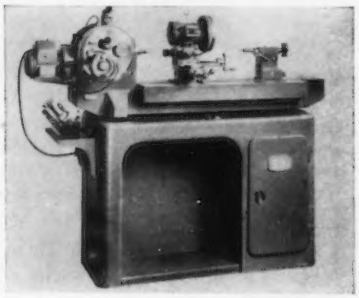
Dispenser speeds up wiring of harnesses, control panels, and electronic assemblies. Unit consists of ten high-impact plastic tubes held in a rack. Saves wiring time because it locates all wires in optimum position for the operator and permits one-at-a-time withdrawal. —Products for Industry Inc.

Circle 168 on Inquiry Card for more data



Optical Tool

Optical dividing head is for workshop or laboratory use. Working accuracy is claimed to be + 2 seconds of a degree.



Suitable for production use as well as an inspection tool. Can be used for all parts that need extreme accuracy of angular spacing. Where light machining operations are contemplated it is possible to drive the head by means of a small detachable motor.—E. Leitz GMBH.

Circle 169 on Inquiry Card for more data

Pneumatic Nibblers

Pneumatic nibblers have a cap. of .064 in. in steel, weigh only 3 lb, and cut at the rate of 6 ft. per minute. Turning radius is 1 in. Intended for intricate contour cutting where size and shape of the work prohibits use of stationary cutting tools.—Newage Industries.

Circle 170 on Inquiry Card for more data

Rocket Propellant Gas Mask

Rocket propellant gas mask and canister provide protection against dangerous elements in hypergolic liquid rocket propellants.

Line includes: gas mask with full face-piece; gas mask with half face-piece; basic rocket propellant canister with standard threaded nozzle; and special military type canister with added filter protection against radioactive and bacteriological dusts.—Willson Products Div., Ray-O-Vac Co.

Circle 171 on Inquiry Card for more data

Plastic Tote Box

Plastic container has been developed as a re-usable storage or tote box. Manufactured of Marlex high density polyethylene, it is easily cleaned or sterilized.

Laboratory tests showed the containers failure-free when dropped from a height of eight feet on each

side and bottom while holding 92 lb. Each container weighs six lb. and measures 16 in. x 20 in.—Como Plastics Inc.

Circle 172 on Inquiry Card for more data

Complete

NONDESTRUCTIVE TESTING

SALES

- Ultrasonic Systems
- Low Frequency Adaptors
- Manipulators
- Standard Reference Blocks
- Ultrasonic Transducers (crystals)
- "Fokker Bond Tester"
- "Datran" Strain Gauge Equipment
- "Ultragraph" Ultrasonic Recorders
- Tire Testing and Recording Systems
- Research and Applications

SERVICES

- Magnetic Particle
- Fluoroscopic
- X-Ray
- Fluorescent Penetrant
- Ultrasonic Thickness Measuring
- Ultrasonic Facsimile Flaw Recording
- Bond Test—Metal to Metal, brazed and cemented, honey comb brazed and cemented by "Ultragraph" facsimile recordings technique
- Corrosion detection by Ultrasonics

AUTOMATION INDUSTRIES, INC.

Ultrasonics Division

7750 Monroe Street Paramount, California

NEvada 6-9841

Circle 23 on Inquiry Card

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Airborne hydraulic systems are especially sensitive to ferrous particles which may wear off moving steel parts and cause sticking of valves, pistons and other finely fitted components. Remove these particles — even in microscopic size with FERROFILTERS. Made for operating at 3000 to 5000 psi.

Write for Brochure

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P. O. Box 1138 Trenton 6, N. J.

Circle 24 on Inquiry Card

Worth Asking For

Story of Prices

An informative booklet comparing past and present "standard of living." —*E. I. du Pont de Nemours & Co.*

Circle 35 on Inquiry Card for more data

HA/HV Leads & Terminals

Illustrated booklet containing specs on leads and terminals for high altitude, high voltage power transmission.—*AMP Inc., Capitron Div.*

Circle 36 on Inquiry Card for more data

Precision Pressure Measuring

Catalog of precision pressure test gauges for use as test standards.—*Heise Bourdon Tube Co.*

Circle 37 on Inquiry Card for more data

Avien Facilities

Colorful brochure describes operations, personnel and capabilities.—*Avien Inc.*

Circle 38 on Inquiry Card for more data

Runway Scarecrow

Bulletin on operation and effectiveness of the Zon automatic scarecrow. —*B. M. Lawrence & Co.*

Circle 39 on Inquiry Card for more data

Science Center

Brochure describes activities at new Science Center in California.—*Hoffman Electronics Corp.*

Circle 40 on Inquiry Card for more data

High Pressure Compression

New bulletin (#189) presents high pressure packaged compressor systems.—*Clark Bros. Co.*

Circle 41 on Inquiry Card for more data

Space Facility Capability

Brochure on potential of Mauna Kea for Space Vehicle launching operations.—*State of Hawaii.*

Circle 42 on Inquiry Card for more data

Anti-Icing Additive

Updated brochure on "Anti-Icing Additives for Jet Fuels."—*Phillips Petroleum Co.*

Circle 43 on Inquiry Card for more data

Beryllium Applications

Illustrated brochure on the application of beryllium metal for nuclear-aerospace uses.—*The Beryllium Corp.*

Circle 44 on Inquiry Card for more data

Spiralloy

An introduction to Spiralloy filament-wound, resin-bonded glass fiber. —*Hercules Powder Co., Inc.*

Circle 45 on Inquiry Card for more data

Controlled Temp Soldering

Literature describes Magnastat controlled temperature soldering irons.—*Weller Electric Corp.*

Circle 46 on Inquiry Card for more data

Magnet Separator

Brochure on FerroFilter permanent magnet separators.—*S. G. Frantz Co.*

Circle 47 on Inquiry Card for more data

Singer-Bridgeport

New 20-page brochure describes technical capabilities.—*Singer-Bridgeport.*

Circle 48 on Inquiry Card for more data

Indexing Tables

Illustrated technical catalog on high-precision Ultradex indexing tables.—*A. A. Gage Co.*

Circle 49 on Inquiry Card for more data

Stabilized Plastic Tube

Engineering report on Impolene, new stabilized polypropylene tubing. —*Imperial-Eastman Corp.*

Circle 50 on Inquiry Card for more data

Digital Recording Systems

20-page brochure describes applications for digital tape recording techniques.—*Minneapolis-Honeywell Regulator Co.*

Circle 51 on Inquiry Card for more data

3-Inch Oscilloscopes

Colorful 16-page presentation of portable oscilloscopes with 3-inch cathode-ray tubes.—*Tektronix, Inc.*

Circle 52 on Inquiry Card for more data

Suit Ventilation

Booklet on full pressure suit ventilator with conditioned air.—*A. J. Sawyer Co.*

Circle 53 on Inquiry Card for more data

Investment Casting

Report on American investment casting industry.—*Wai Met Alloys Co.*

Circle 54 on Inquiry Card for more data

Radial Drilling

Bulletin (#BR-11) describes new Bickford 11 inch radial drilling machine.—*Giddings & Lewis Machine Tool Co.*

Circle 55 on Inquiry Card for more data

Microcircuitry

Technical data sheet on thin film integrated circuitry for use in microminiaturization of circuits. — *Halex, Inc.*

Circle 56 on Inquiry Card for more data

Emerson's GED

Resources and capabilities of the Government Electronics Div. are described in this booklet. — *Emerson Radio & Phonograph Corp.*

Circle 57 on Inquiry Card for more data

High Temp Plastics

Brochure on plastics for high temperature applications.—*Goodyear Aircraft Corp.*

Circle 58 on Inquiry Card for more data

Gyros

Bulletin describes free, vertical and directional gyros.—*General Precision Inc., Kearfott Div.*

Circle 59 on Inquiry Card for more data

Lead-Lithium Survey

Annotated bibliography on lead-lithium alloys.—*Foote Mineral Co.*

Circle 60 on Inquiry Card for more data

Teflon Ring Seals

Brochure (TF-010) on Teflon piston ring seals and seal sets.—*Tetraflour, Inc.*

Circle 61 on Inquiry Card for more data

Hastelloy Revised

Revised booklet on Hastelloy alloy B, a high-temp and corrosion resistant nickel-base alloy.—*Haynes Stellite Co.*

Circle 62 on Inquiry Card for more data

Cylindrical Standards

Illustrated booklet entitled "Gaging Shortcuts."—*Deltronic Corp.*

Circle 63 on Inquiry Card for more data

Synchro Transmitters

Bulletin (S-608) on low and high pressure transmitters. Bulletin (S-609) describes matching repeaters.—*Servonic Instruments, Inc.*

Circle 64 on Inquiry Card for more data

Dry Boxing Gloves

Brochure on sleeves and gloves with hand temp suppressors for dry box use.—*Wilson Rubber Co.*

Circle 65 on Inquiry Card for more data

High Alumina Ceramics

Bulletin (121) describes high heat and wear resistant ceramics.—*Duramic Products, Inc.*

Circle 66 on Inquiry Card for more data

Fine Wire

Complete data on fine wire for electronics. — *Consolidated Reactive Metals, Inc.*

Circle 67 on Inquiry Card for more data

Brazing Alloys

Folder on vacuum-melted brazing alloys.—*Metallurgical Products Dept., General Electric Co.*

Circle 68 on Inquiry Card for more data

Bending and End-Finishing

News leaflet on bending and end-finishing machines.—*Pines Engineering Co.*

Circle 69 on Inquiry Card for more data

Abradable to Zirconium

Catalog of products and facilities. —*Union Carbide Corp.*

Circle 70 on Inquiry Card for more data

X Marks The Spot

Bulletin (GEA-6596) on "Position-Indicating Instrument Systems" for aviation industry. — *Instrument Dept., General Electric Co.*

Circle 71 on Inquiry Card for more data

Magnetohydrodynamics

Catalog discusses field, research "tools" and company's areas of research.—*MHD Research Inc.*

Circle 72 on Inquiry Card for more data

Instrument Servos

Catalog (SFC-1) deals with vacuum tube and all-solid-state servo indicators and repeaters.—*North Atlantic Industries Inc.*

Circle 73 on Inquiry Card for more data

Voltage Digitizers

Technical data sheets on two models.—*Adage Inc.*

Circle 74 on Inquiry Card for more data

Adjustable Speed Drives

Bulletin (GEA-7208) on drives using silicon controlled rectifiers instead of tubes.—*Specialty Control Dept., General Electric Co.*

Circle 75 on Inquiry Card for more data

Mixer Torches

Booklet on mixer type welding torches.—*Linde Co., Division of Union Carbide Corp.*

Circle 76 on Inquiry Card for more data

Flexible Hose

Bulletin (#605) on flexible hose and duct.—*Flexaust Co.*

Circle 77 on Inquiry Card for more data

Self Manifolding Valve

Brochure presents new building block valve featuring balanced poppet and symmetrical body design.—*Marotta Valve Corp.*

Circle 78 on Inquiry Card for more data

Rubber Products

Condensed catalog on line of rubber products for industry.—*Manhattan Rubber Div., Raybestos-Manhattan Inc.*

Circle 79 on Inquiry Card for more data

Diffusion Coatings

Oxidation-resistant surface coatings for metals and alloys are described in this brochure. — *Haynes Stellite Co., Division of Union Carbide Corp.*

Circle 80 on Inquiry Card for more data

Boring Bars

New 24-page catalog of boring bars and related tools.—*Giddings & Lewis Machine Tool Co.*

Circle 81 on Inquiry Card for more data

Trimmer Resistors

Data sheets (177 & 178) describe 42-turn square and 25-turn rectangular trimmer resistors.—*CTS Corp.*

Circle 82 on Inquiry Card for more data

Alloy Casting

Catalog on custom alloy steel castings.—*ESCO Corp.*

Circle 83 on Inquiry Card for more data

Heavy Duty Presses

Brochure on 15" heavy duty drill presses.—*Clausing Div., Atlas Press Co.*

Circle 84 on Inquiry Card for more data

Microwave Power Attenuator

Bulletin (#578) describes models for frequency range from DC-2000 MC.—*Empire Devices Inc.*

Circle 85 on Inquiry Card for more data

Please Curb Your Imports

Booklet on campaign to counter electronic imports from low-wage foreign sources. — *Electronic Industries Association.*

Circle 86 on Inquiry Card for more data

Thin Section Bearings

Bulletin (S-109) suggests replacement of small bore heavy section bearings with 4" to 40" bore thin section bearings. — *Kaydon Engineering Corp.*

Circle 87 on Inquiry Card for more data

GE Plastics Guide

Brochure describes complete line of polycarbonate resins, phenolic resins, varnishes and molding powders, and fused magnesium oxide.—*Chemical Materials Dept., General Electric Co.*

Circle 88 on Inquiry Card for more data

Power Packages

Bulletin on power packages with 40-40,000 volt outputs.—*Amp Inc.*

Circle 89 on Inquiry Card for more data

Steel-Bonded Carbide Tools

Technical article "Some Properties and Metallography of Steel-Bonded Titanium Carbide."—*Sintercast Div., Chromalloy Corp.*

Circle 90 on Inquiry Card for more data

Environment-Free Switches

Catalog (#130) of hermetically-sealed and environment-free switches. —*Controls Co. of America, Control Switch Div.*

Circle 91 on Inquiry Card for more data

Balancing Machines

20-page brochure discusses principles and sources of unbalance and balancing machines. — *Tinius Olsen Testing Machine Co.*

Circle 92 on Inquiry Card for more data

Microwave Production

Products & facilities are described in this brochure.—*General Precision Inc., Kearfott Div.*

Circle 93 on Inquiry Card for more data

Calculator Kit

New tool for plotting sample sizes of thermostatic bimetal.—*Texas Instruments Inc.*

Circle 94 on Inquiry Card for more data

History of Propulsion

A reprint with illustration of an address by Don L. Walter, V.P., Powers Systems Group.—*The Marquardt Corp.*

Circle 95 on Inquiry Card for more data

Graphite & Carbon Felts

Information on eight grades of plain and reinforced graphite and carbon felts.—*National Carbon Co.*

Circle 96 on Inquiry Card for more data

Honeywell

Brochure outlines activities and advantages of employment by Honeywell.—*Davies Laboratories Div.*

Circle 97 on Inquiry Card for more data

Hardness Tester

Bulletin on portable Brinell Hardness Tester.—*King Tester Corp.*

Circle 98 on Inquiry Card for more data

Super Alloy Tubing

Bulletin (#71) describes Super Alloy Tubing.—*Superior Tube Co.*

Circle 99 on Inquiry Card for more data

Aerospace Components

Facilities for precision sheet metal fabrication are outlined in this illustrated brochure.—*Lavelle Aircraft Corp.*

Circle 100 on Inquiry Card for more data

Building Blocks

New 8-page technical brochure describes the use of high-speed digital system building block modules.—*Harvey-Wells Electronics*

Circle 101 on Inquiry Card for more data

Programmable Power

Manual for Model 221A Regatron programmable power supplies.—*Electronic Measurements Co.*

Circle 102 on Inquiry Card for more data

Silicon Nitride

Booklet on "Haynes Silicon Nitride" covers its high-temp and corrosion resistance.—*Haynes Stellite Co.*

Circle 103 on Inquiry Card for more data

Compact Locknut

Bulletin on lightweight locknut with above average axial tensile strength. —*Standard Pressed Steel Co., Aircraft & Missiles Div.*

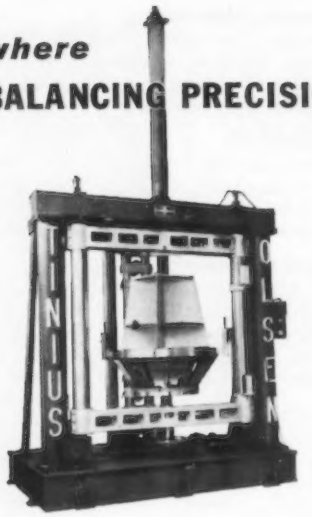
Circle 104 on Inquiry Card for more data

DuMont Lab

Brochure on activities, facilities and capabilities.—*Allen B. DuMont Laboratories*

Circle 105 on Inquiry Card for more data

where
BALANCING PRECISION ***counts...***



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TINIUS OLSEN

From balancing re-entry vehicles to eliminating destructive vibration in jet engines, Tinius Olsen balancing machines play a major role in the aircraft and missile industry.

If it rotates, you can balance it faster and more accurately on an Olsen. Write today for Bulletin 60, about the complete line of Tinius Olsen balancing machines.

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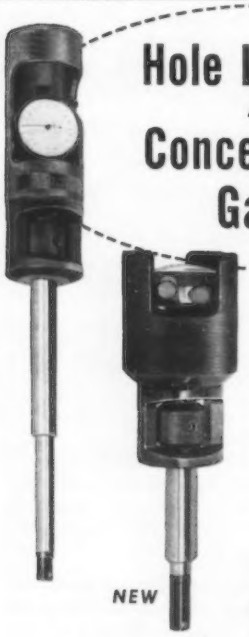
Gages



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- ★ *precision made*
- ★ *hardened and lapped*
- ★ *special models engineered*
- ★ *seven standard models*

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Special Machines
Tools and Gages
Spline Gages

MAYES TOOL CO.
26514 W. SEVEN MILE ROAD
DETROIT 40, MICHIGAN
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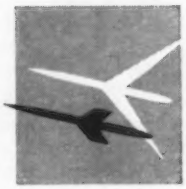

Men on the Move

A. G. Valentine
Magnetic

E. GORMAN and A. G. VALENTINE, appointed development engineers at Magnetic Controls Co.

SOLOMON HUDES, named engineering vice president by Telechrome Mfg. Corp.

CHARLES K. TITUS, named manager, scientific analysis and programming dept., Communication and Data Processing Div. of Collins Radio Co.

Beech Aircraft named BRUCE COOPER manager — southeast military area for diversified space age program.

Micro Gee Products appointed ROBERT W. NOWACK as manager of engineering sales.

CLIFFORD F. ABT, promoted to manager, research dept., Arma Division, American Bosch Arma Corp. He succeeds DR. BERNARD LITMAN who moves on to new scientific staff.

J. WALTER GUYER, appointed director of special projects for Ren Plastics Inc.

LEE HENNESSY, chemist, joined Industrial Electronic Rubber Co. as technical director.

GEORGE M. HINES, appointed president, Orenduff & Cappel Div., Curtiss-Wright.

Standard Rectifier Corp. appointed JACK GILLETTE as associate director of engineering.

Hamilton Watch Co. formed new Precision Metals & Electronic Div. with L. A. HURWITZ as manager. R. M. JACKSON will head electronics product group.

JOHN HULL, elected vice president-manager of Walter Kidde & Company's International Div.

WAYNE D. HUDSON, appointed assistant general manager of Avco's Nashville Div.

SAMUEL RABER joined the engineering staff of Dorne & Margolin, Inc., as section head of the circuit group.

Solomon Hudes
Telechrome

Bernard Litman
Arma

Lee Hennessy
IERI

J. Walter Guyer
Ren

CARL M. NOBLE, elected president of Hurletron Inc., a new firm resulting from merger of Electric Eye Equipment Co. and Wheaton Engineering.

Electronic Materials Corp. elected DR. VICKERY president. He will also direct research for this new firm. HUGH M. MUIR was named vice president.

DENHAM SCOTT, assistant to the president of The Garrett Corp., appointed associate member of the Military Procurement Advisory Committee to the United States Senate.

Hoffman Electronics Corp. has appointed DR. GEORGE WERTWIJN as engineering head of Semiconductor Div.

LEO V. MC NAMARA, named sales manager, Applied Dynamics Div., Atlee Corp.

DALE D. MYERS, named weapon systems manager on Hound Dog program at North American Aviation's Space & Information Systems Div.

Avco Corp. elections place KENDRICK R. WILSON, JR. as board chairman and chief executive officer, JAMES R. KERR as president and COLONEL EARL H. BLAIK as executive committee chairman.

HOWARD W. GROSSBOHLIN, named manager, formed tube products group, Stromberg-Carlson-San Diego.

JACK R. SNYDER, promoted to sales manager, Seezak Div., Rimak Electronics Inc.

MARK ROSEN has joined Datex Corp. as development engineer.

TEMEC Inc., new facility of Cubic Corp. of San Diego, elected WILLIAM FALSTROM president.

Antenna Systems Inc., appointed MERLE C. SHERMAN financial vice president.

WILLIAM P. SHARPE, JR. has joined International Resistance Co. as marketing manager, high reliability resistors.

GEORGE BUTLER, named director of new potentiometer group at International Resistance Co.

ALFRED V. GANGNES, named director of marketing for Interstate Electronics Corp.

Daytex Corp. elected MICHAEL J. JONCICH vice president.

Carl M. Noble
Hurletron

Bruce Cooper
Beech

Charles K. Titus
Collins

Robert W. Nowack
Micro Gee

E. Gorman
Magnetic

Clifford F. Abt
Arma

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This copy, for example, was prepared on a VARITYPER (Model 610). The Headliner was photo-composed on the HEADLINER.

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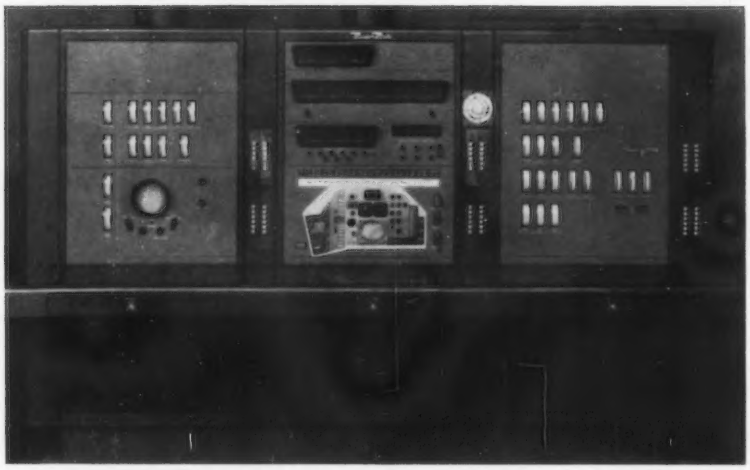
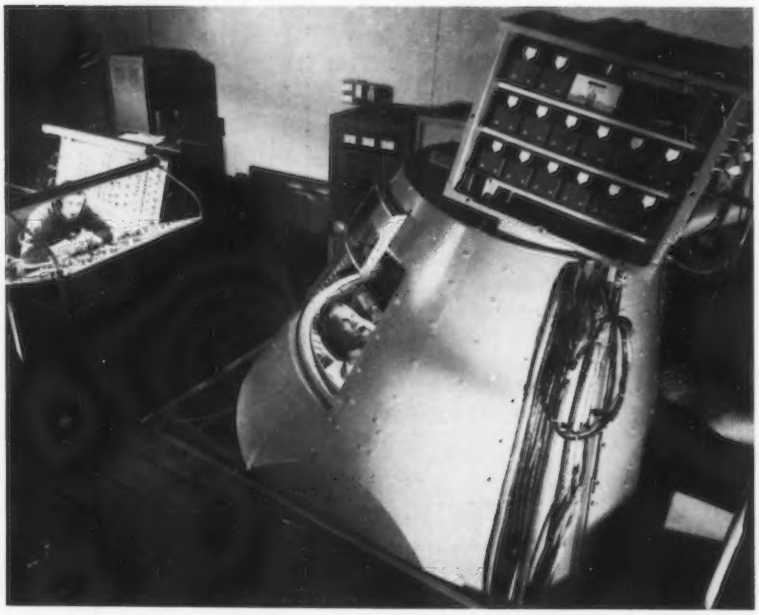
Circle 26 on Inquiry Card

Industry Notes



FLIGHT CONTROLLERS will use medical monitor (left), communications panel (center) and systems monitor (right). Capsule elapsed time and time of retro-fire show on top central section. Horizontal row of panels (bottom center) lights as retro and re-entry sequences occur.



PROCEDURES TRAINER was developed by McDonnell aircraft for astronaut training at NASA's Space Task Group. Controller (left) checks responses of astronaut John Glenn to simulated capsule problems.

Mercury Checkout

Project Mercury tracking stations are undergoing pre-mission checkout. Teams from industry, the Department of Defense and NASA are now training for the job of manning them.

Ground electronic apparatus at a fully-equipped tracking station includes medical monitoring, communication control, and capsule systems monitoring.

A three-man team at each station can handle the threefold flight-control duties. Department of Defense is training men for the medical monitoring. NASA will supply the communicators. Philco Corp. specialists will handle spacecraft systems monitoring.

The communicator can talk with the man in orbit by UHF or HF voice links. He may also reach the Astronaut by Morse code once a button on the spacecraft's instrument panel is pushed. Communicator participates in any decision to reset the sequence for firing retro rockets. He may trigger a new retro sequence himself by a guarded switch on his panel.

Medical monitors watch body temperature, pulse, respiration rate, electrocardiogram, cabin temperature and pressure. System monitors watch attitude, pitch, roll, and yaw motion, fuel, plus cabin and suit oxygen supply, temperature, and pressure.

Spacecraft is to be in contact with each ground station for a minimum of five minutes per pass. Longest interval without contact will be 20 minutes. Tracking information must provide continuous impact prediction. Error of 15 sec in retro sequence will place the spacecraft outside the prime recovery zone.

Astronaut is equipped to work along with the ground stations. He

can rely on "dead reckoning" if in predicted orbit; using map laid off at one min. intervals, clocks, computer, earth path indicator, periscope (ground reference), and window (celestial reference).

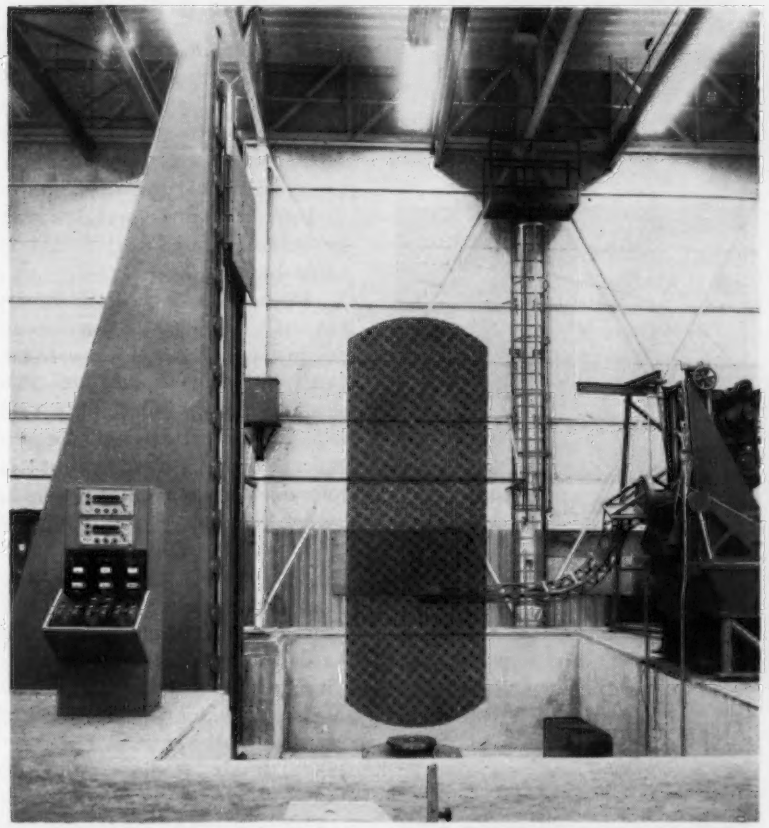
The Mercury tracking network includes three land stations in Africa, two modified Atlantic Missile Range ships, two stations in Australia, stations in Canton Island, and Hawaii. The 14 stations are coordinated by Mercury Control Center at Cape Canaveral. Many of the stations will be linked by point-to-point communications. Data on performance of man and spacecraft will be transmitted to network headquarters at Goddard Space Flight Center, Greenbelt, Md.

NASA has been simulating orbital data by telemetering information to ground stations from instrument-laden aircraft. The astronauts themselves are trained in communication techniques from practice on McDonnell Procedures trainer, centrifuge, and other equipment.

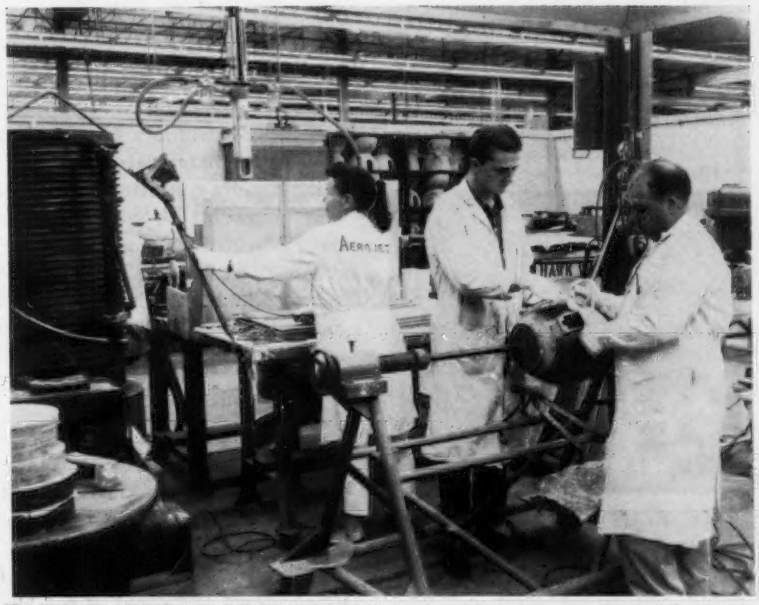
Western Electric is prime contractor for Project Mercury tracking and ground instrumentation. Bendix-Pacific furnishes telemetry equipment. Bendix-Radio furnishes voice channel equipment and tracking radar. Other subcontractors include IBM (programming and computers), Burns & Roe (ground station construction), Bell Telephone (systems analysis), Westinghouse Electric (air conditioning) and Dresser Ideco Co. (antenna support towers).

New Standard Adopted For Clearing Personnel

The Department of Defense now has a revised set of rules for determining whether or not defense contractors and their employees may have access to classified information. The new DOD directive (No. 5220.6) extends the Armed Forces Industrial Security Regulation to cover classified contracts of NASA and the Federal Aviation Agency.



POLARIS A-3 TEST CASES are produced on large new filament winding machine at Aerojet-General. Shaded area shows estimated size of first stage case (54 inch diam., 160 inch length). Aerojet and Hercules Powder are working on cases for the A-3.



HAWK WARHEAD PRODUCTION is shown at Aerojet General's Structural Materials Div. plant. Roughly the same techniques also produce Nike Hercules warheads.

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Industry Notes

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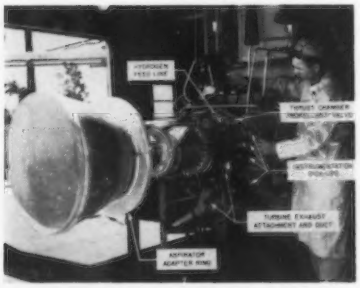
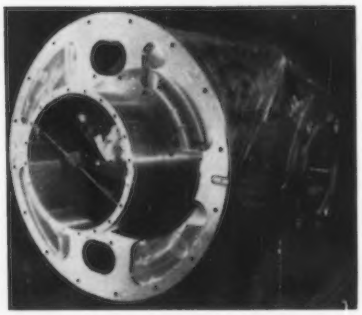


FLUORINE ROCKET ENGINE at Bell Aerosystem Co. has completed extended test firings. Results indicate feasibility of fluorine-hydrogen rocket.

CENTAUR BOOSTER in final assembly at Convair-San Diego. Airframe, just beyond Atlas in foreground, has constant 10 ft diam without tapered forward end.



NIKE ZEUS missile-tracking part is machined and heat-treated at Boeing-Wichita. Surfaces at opposite ends of this 4200 lb. aluminum weldment were machined to 0.002 inch tolerances.

R & D Briefs

B-70 fuel-inerting system is now being tested in a simulator at North American Aviation. It maintains pre-selected pressure and predetermined atmosphere in the fuel tanks to reduce auto-ignition hazards. Prototype equipment was developed by Parker Aircraft and Arthur D. Little Inc.

Inland Testing Laboratories, Div. of Cook Electric Co., is conducting tests of 160 nickel-cadmium batteries at low temperatures such as would prevail in satellites. Tests will be varied throughout the year under Wright Air Development Div. contract. Resultant information on battery life will be distributed to industry.

Anti-missile program is expected to benefit from basic research on high temperature air at Avco Everett Research Laboratory. Air Force contract calls for year-long investigation of interaction of electromagnetic waves with 9000°-25,000°F air. Radio waves have been unable to penetrate some ionized high temperature gages surrounding re-entering space vehicles.

High-temperature materials to store heat are under investigation at General Electric (MSVD). The heat storage method is for use in solar thermionic conversion systems, collecting heat from the sun by means of large reflectors. These reflectors concentrate the energy and focus it within a heat receiver.

Russian industrial production is being rapidly converted to automation, according to a report from the Mathematics Center of Martin's RIAS (Research Institute for Advanced Studies). The report predicts that the Soviet Union will move at a faster rate than the U. S. in applying mathematical theories to automation and aerospace.

Minuteman capacitors are under accelerated life testing at General Electric. Firm is seeking reliability levels of 99.9 per cent per 1000 hr. of operation.

New missile warning system is under study at Loral Electronics Corp. for the Air Force.

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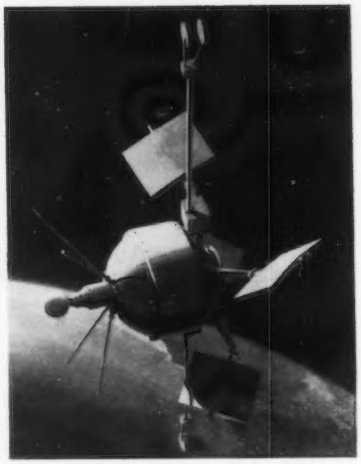
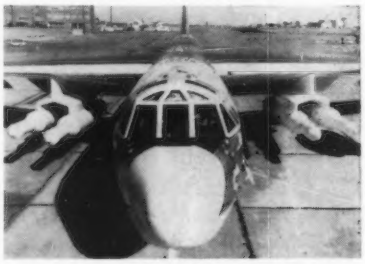
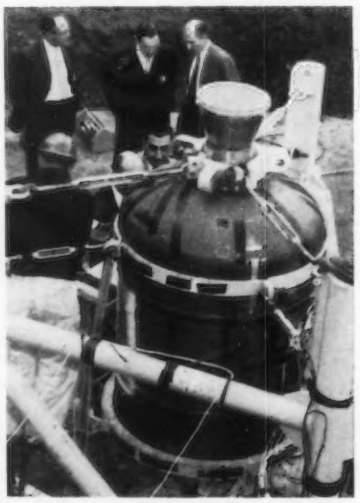


FIRST BRITISH SATELLITE, the S-51, is slated for launching by Scout in about a year. This NASA-United Kingdom satellite will carry boom to measure electron density.



SKYBOLT MISSILES are mounted on pylons under each wing of B-52H production model. Skybolt, operational in about 3 years, has 1000 mile range against ground targets.



SEGMENTED ROCKET MOTOR was recently fired successfully at United Technology Corp.

Communications satellite for 22,000-mile-high orbit has been built by Hughes Aircraft Co. It is 29 inches in diameter and weighs only 32 lb.

Gases superheated by ultrasonic shock waves to temperatures of 5,000 to 21,000°F are yielding basic data that may lead to design of new missile-detection systems at Convair (San Diego). Experiments are being conducted in a new shock tube, simulated altitudes up to 150,000 ft.

Ammonia has been experimentally transformed into hydrazine in a nuclear reactor at Aerojet-General Nucleonics. Aerojet placed a capsule of ammonia and uranium in a low-power reactor. Radiation of the capsule caused fission fragments of uranium to break up molecules of ammonia and re-form them into hydrazine.

Lens-studded satellites are now under development at the Air Research and Development Command's Wright Air Development Div. Satellite is covered with radio frequency lenses mounted over spherical reflectors. It is designed so that no matter which position the satellite assumes with regard to the earth, strong reflection of signals will take place between ground stations 6,000 miles apart.

Segmented solid propellant rocket motor has been test fired at United Technology Corp.'s rocket motor Development Center. It is a conical design.

Ultrasonic wind measuring is the aim of new project at Emerson Radio & Phonograph Corp. Firm is developing ultrasonic device to measure velocity of winds behind aircraft carriers.

Disil process coating is being used on molybdenum at Boeing-Seattle. Firm reports good self-healing properties above 2500°F with stability at more than 3200°F.

Parawing devices, used in studies at NASA's Langley Research Center, gave threefold increase in lift coefficient of supersonic canard bomber models at airplane attitude of 12°.

Solar optical communications system, under development at Electro-Optical Systems Inc., collects sun's rays in mirror antenna, then funnels it through modulator for coding and into a second mirror system for emission through space to another vehicle. Firm believes 10-million-mile range is feasible.

Disil process is being used in tests at Boeing-Seattle to protect spacecraft structures from re-entry heat. It involves application of silicon and other materials to the surface of molybdenum.

Production Techniques

Computer reporting system is now operational at Rocketdyne to process data generated by liquid propellant rocket engine tests.

14-ton vacuum furnace is now in use at Convair (Astronautics) for heat-treating metals for use in Atlas and Atlas-Centaur. Furnace can anneal, homogenize and temper metals for flight temperatures from –423° to 2150°F.

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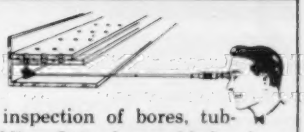

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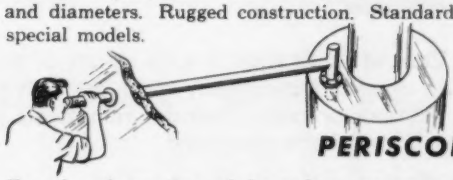

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6 **High strength-to-weight ratio.** In terms of weight, reinforced plastics are considerably stronger than most metals. Moreover, their strength characteristics may be directed where stresses demand. In filament or tape wound shapes, highest properties may be obtained.

5 **Comparative rigidity in cured condition.** This property prevents the reinforced plastic part from bulging or otherwise deforming when high pressures or other stresses are present. Thus original tolerances can be maintained under adverse operating conditions.

4 **Excellent corrosion resistance.** High resistance to both atmospheric and chemical corrosion is a feature of reinforced plastics. This is particularly important in structural members where corrosion could generate failure locations.

3 **Low heat transfer.** This, under extremely high temperatures, makes Tayloron ideal for protecting structural members in missiles.

2 **Good ablation qualities.** The capacity to keep on performing their basic function despite loss of some of their structure is an important characteristic true of some reinforced plastics. Tayloron materials offer the additional advantages of dissipating energy and thus reducing stresses on other members.

1 **Ease of fabrication.** A wide variety of shapes may be made to close dimensions by molding, laminating, or winding of filament or tape. Tayloron reinforced plastics are readily fabricated and machined.

How Taylor Can Help You

In your designing of components and assemblies, consult our Advanced Materials Division on how to choose the best material and minimize the cost in reinforced plastics. Taylor can supply complete fabricated assemblies—or materials for any test and evaluation program. Special Tayloron materials have been developed for many specialized applications. Write the Advanced Materials Division outlining your specific problem. Taylor Fibre Co., Norristown 50, Pa.

*Trade name for Taylor Fibre's space, missile and astronautic materials

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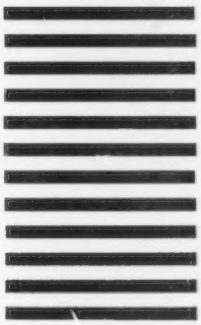

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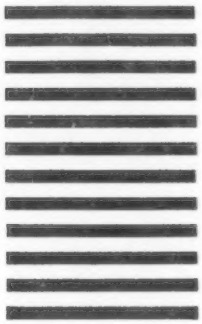

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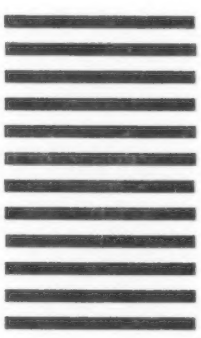

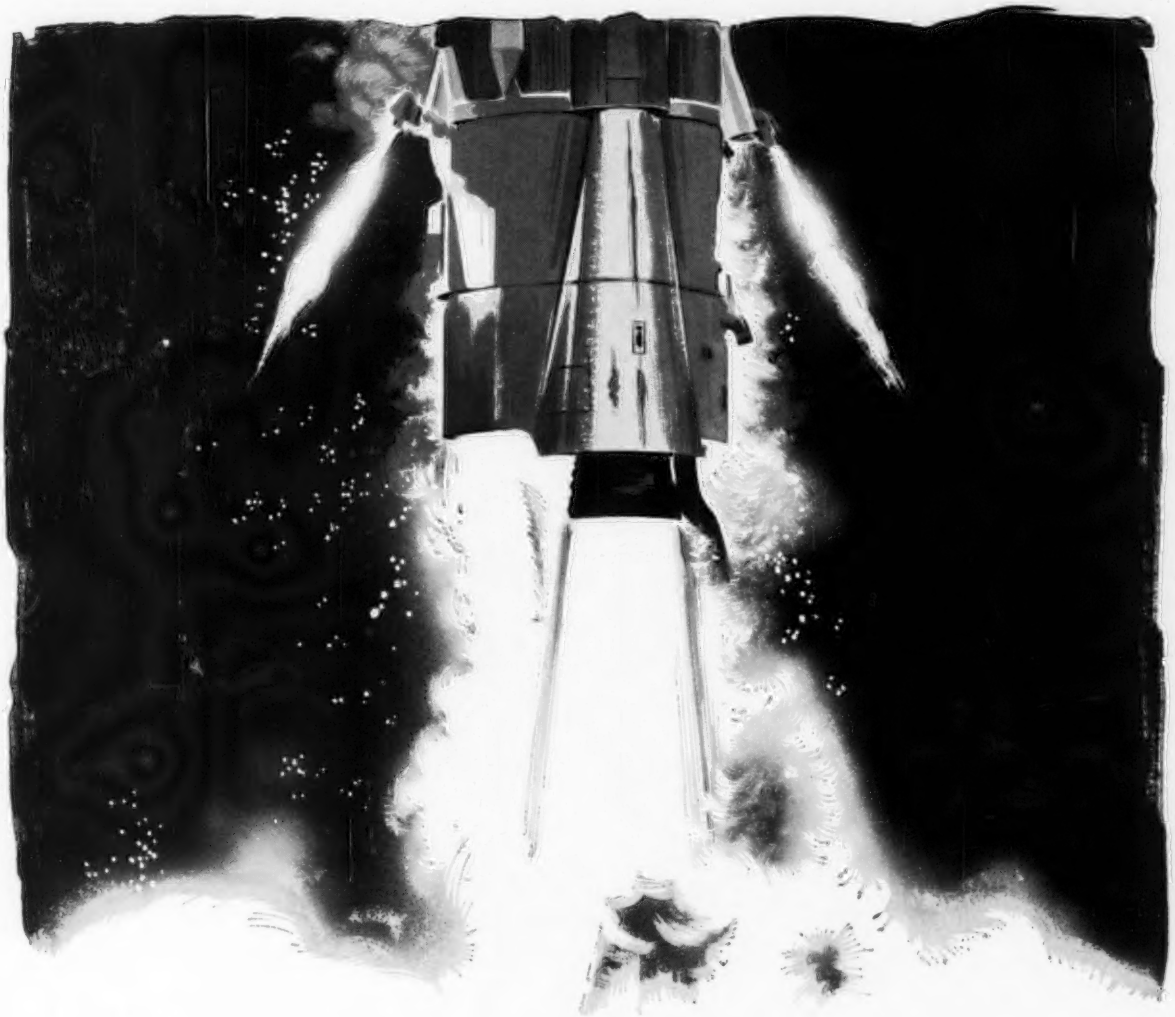

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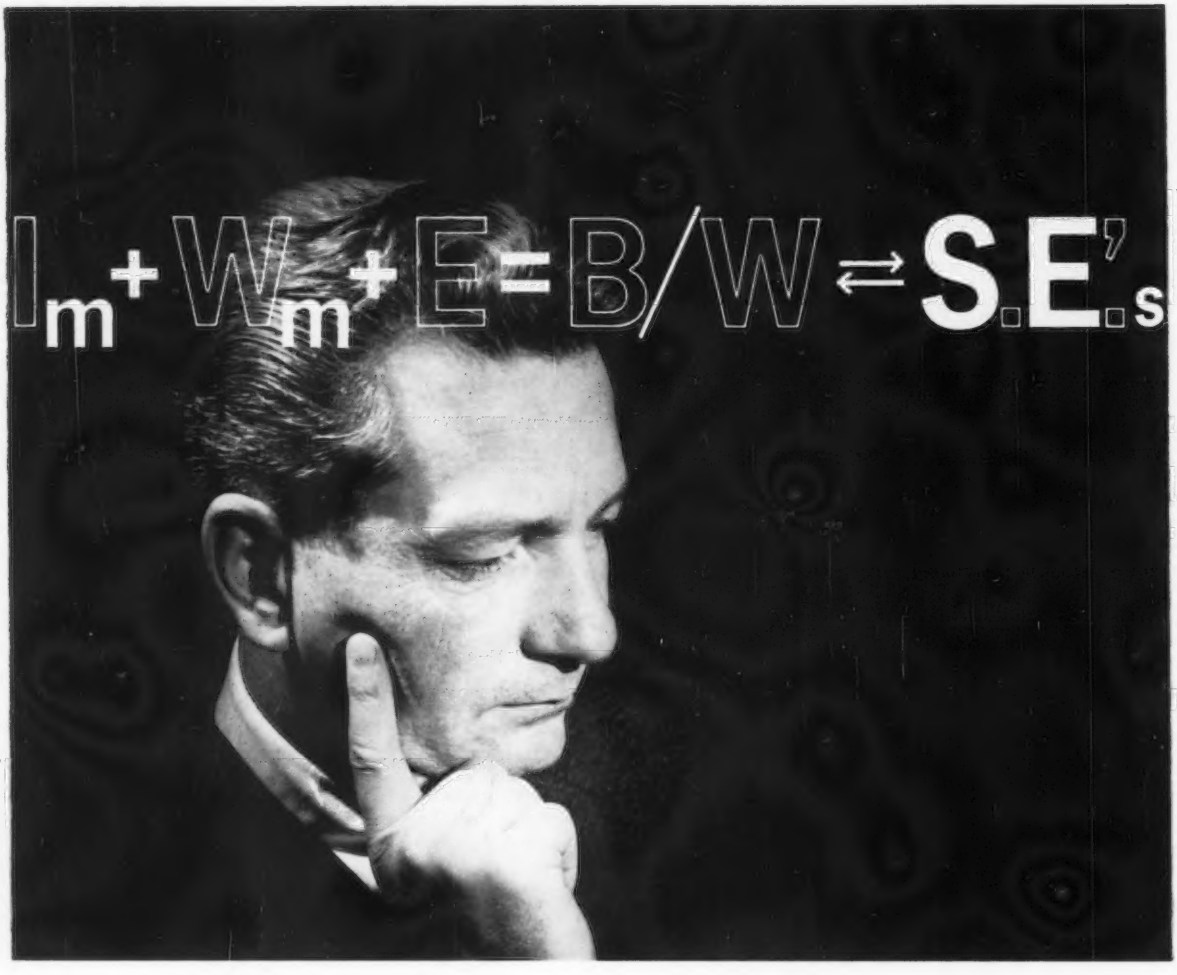

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